THE ENGINEERING MAGAZINE
THE WORLD IS ITS FIELD

VOL. XXVII. AUGUST, 1904. No. 5.

NATURAL CONDITIONS AFFECTING THE CONSTRUCTION OF THE PANAMA CANAL.

By Gen. Henry L. Abbot.

WE are glad to be again the means of presenting to the engineering world General Abbot's most valuable studies of the conditions to be met in the building of the Panama Canal. There is no higher authority on the hydrology and climate of the Isthmus, and nowhere else such a fund of exact and exhaustive data as is at General Abbot's command. It is by the definite knowledge and the correct interpretation of these facts that the great key problems of the construction work must be decided—THE EDITORS.

NOW that the completion of the canal has been definitely assumed by the United States, and the attention of American engineers and others is attracted to the numerous problems involved in the works of construction, it seems desirable to supplement my paper on the Regulation of the Chagres River, which appeared in THE ENGINEERING MAGAZINE for December, 1902, with a view not only to bringing these invaluable records of the New Company up to date, but also to considering some other matters of practical importance to those contemplating participation in the work.

Among these other matters is the volume, and especially the distribution, of rainfall in the different months of the year. As is well-known, there is a sharp division between the rainy and dry seasons; the respective volumes are shown in the following table which is a summary of the monthly observations of the officers of the Canal Company and of the Panama Railroad from the earliest dates up to the transfer of the property at the end of April, 1904. Figures in brackets denote the number of years covered by the records.

Copyright, 1904, by John R. Dunlap.

TABLE I. CONSOLIDATED RECORDS OF RAINFALL IN INCHES.

	Atlantic.		Interior Stations.						Pacific Coast.		
Month.	Colon. (33)	Bohio. (7)	Alhajuela. (4)	Gamboa. (21)	Gorgona. (3)	Bas Obispo. (10)	Culebra. (5)	Panama. (4)	Naos. (7)	Taboga. (3)	La Boca. (5)
Jan.	4.0	9.0	1.3	2.4	3.3	1.8	0.9	0.7	0.5	0.2	2.1
Feb.	1.4	1.8	0.3	0.7	0.6	0.4	0.2	0.7	0.1	0.0	0.1
Mar.	1.6	2.3	0.7	0.9	1.2	0.8	0.3	1.6	0.4	0.0	1.9
Apl.	4.2	5.3	4.9	3.5	2.4	2.7	2.0	2.8	1.7	0.8	4.0
May	12.1	13.3	11.7	10.9	11.6	10.9	12.0	7.6	4.8	6.3	9.2
June	13.4	12.6	12.3	9.6	9.3	11.7	10.2	7.9	5.5	8.2	7.1
July	16.7	17.1	14.7	10.3	13.3	8.8	7.6	7.6	4.3	6.2	9.5
Aug.	15.1	19.2	12.9	12.7	14.2	9.8	8.9	6.8	4.8	7.1	7.2
Sept.	12.6	16.6	11.8	10.9	13.5	12.2	9.1	7.5	7.4	7.3	6.7
Oct.	14.0	18.0	14.9	13.1	11.2	10.5	11.7	9.5	6.6	7.3	9.9
Nov.	20.9	20.3	16.1	12.2	10.4	10.6	11.3	11.6	6.3	4.1	10.1
Dec.	12.3	10.6	7.5	7.0	5.5	9.1	11.2	2.8	3.2	6.6	5.6
Year	128.3	146.1	109.1	94.2	96.4	89.3	85.3	66.8	45.5	54.0	73.4

To aid in estimating the number of rainy days probable in each month, a table giving a complete record for a few years, with their averages, seems to be preferable to one presenting simply averages for longer periods, since it reveals the annual variations. Such a table is the following, covering the last five years at stations where most work will be required. Each day in which rain fell is included. It would appear that the rainfall at Bohio is not only larger in volume but is also more frequent than at any other point of the canal line. Further in the interior, where are found the heaviest excavations, a safe monthly estimate would seem to be one week of rainy days and half an inch of rain in the dry season, and three weeks and twelve inches in the rainy season; but it must not be forgotten that on many of these days very little rain falls.

TABLE II. NUMBER OF RAINY DAYS PER MONTH.

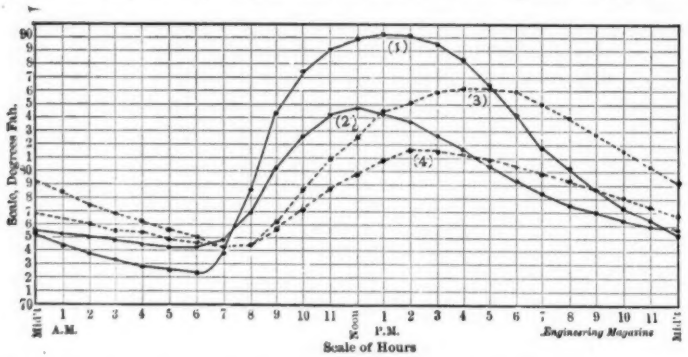
	COLON.						
Month.	1899.	1900.	1901.	1902.	1903.	1904.	Means.
January	19	11	13	19	9	17	15
February	12	4	4	5	5	7	6
March	4	5	6	9	12	7	7
April	3	4	5	14	11	17	9
May	17	17	15	20	20	..	18
June	18	22	17	17	16	..	18
July	25	23	22	19	18	..	21
August	21	24	25	13	23	..	21
September	20	18	21	20	23	..	20
October	15	23	26	20	18	..	20
November	15	25	28	23	26	..	23
December	13	14	23	15	25	..	18
Year	182	190	205	194	206	..	196

TABLE II. NUMBER OF RAINY DAYS PER MONTH.—*Continued.*

Month.	1899.	1900.	1901.	1902.	1903.	1904.	Means.
BOHIO.							
January	23	17	11	24	10	26	19
February	18	5	8	3	4	11	8
March	13	8	11	5	10	16	11
April	7	6	11	14	10	20	11
May	17	27	28	(23)	20	..	23
June	26	27	22	20	19	..	23
July	25	31	30	20	21	..	25
August	30	29	29	21	27	..	27
September	25	28	27	20	26	..	25
October	21	30	29	24	28	..	26
November	19	28	30	21	30	..	26
December	20	20	22	16	30	..	22
Year	244	256	258	188	235	..	246
ALHAJUELA.							
January	..	8	5	(7)	4	12	7
February	..	1	1	2	(2)	2	2
March	..	1	3	3	3	5	5
April	..	9	5	16	3	10	9
May	..	18	25	(22)	22	..	22
June	..	24	22	27	24	..	24
July	20	26	21	23	29	..	24
August	21	22	25	20	27	..	23
September	20	19	23	18	18	..	20
October	21	20	16	26	23	..	23
November	21	20	27	24	27	..	24
December	11	10	16	12	25	..	15
Year	..	178	199	200	207	..	198
GAMBOA.							
January	13	7	5	17	6	16	11
February	8	2	2	3	2	2	3
March	7	2	1	13	3	10	6
April	6	9	5	22	6	20	11
May	11	18	20	(18)	23	..	18
June	23	23	21	16	19	..	20
July	19	22	21	20	24	..	21
August	21	21	21	19	26	..	22
September	18	15	16	21	23	..	19
October	14	24	25	25	22	..	22
November	16	24	27	26	25	..	24
December	10	8	16	10	23	..	13
Year	166	175	180	210	204	....	190
LA BOCA.							
January	..	2	(6)	8	5	9	6
February	..	0	(1)	1	0	3	1
March	..	0	(4)	4	1	10	4
April	..	5	(7)	6	5	13	7
May	..	6	14	12	18	..	12
June	..	17	18	7	9	..	13
July	..	9	17	8	24	..	15
August	..	10	16	21	21	..	17
September	20	..	19	14	15	..	17
October	18	..	22	20	21	..	20
November	16	..	19	17	20	..	18
December	6	..	11	7	19	..	11
Year	109		154	125	158	..	141

Many inquiries are made about the temperature of the Isthmus. The monthly averages hardly vary throughout the year along the line of the canal. Well distributed observations covering 309 months indicate a variation of only 2.7 degrees Fah. between the coolest month (January, 78.3 degrees) and the hottest month (June, 81.0 degrees). The annual mean is 79.7 degrees.

A similar uniformity does not appear in the hourly diurnal variations. They show well marked difference in the rainy and dry seasons, and also in the interior and on the coast. Five years of observations with self-recording thermometers at Alhajuela and at La Boca have made these differences known with precision, and as they are not without importance in regulating the hours of work the following table has been prepared to indicate them; in it "maxima" and "minima" refer to absolute extremes as recorded during the entire period under each heading. As appears from Table II, the months of January, February, March, and April during these five years should be accounted as dry, and the other months as rainy. The characteristic differences between seasons are largely due to different hygrometric conditions of the atmosphere, which affect radiations from the sun and specially from the earth. This is made manifest when temperature curves of exceptionally dry or rainy months are compared with the average for their season, and for this reason the means for March and November are added to the following table. They are the extreme months in respect to precipitation, and show in a slightly exaggerated



MEAN DAILY TEMPERATURE IN DEGREES F. FIVE-YEAR MEANS OF EXTREME DRY AND RAINY MONTHS. PLOTTED FROM TABLE III.

1, Alhajuela in March; 2. Alhajuela in November; 3, La Boca in March; 4, La Boca in November. Alhajuela is on the Upper Chagres, 144 feet above mean tide; La Boca is on the Bay of Panama, at about sea level.

form the characteristic temperature differences between seasons, as will be noted by comparing the figures in the table. These extreme types have been selected to be shown on the plate, where they present the normal differences, due to season and locality, so clearly to the eye that little need be added in words. The table, representing over 80,000 readings of the thermometer, certainly demonstrates that although the monthly mean temperatures are sensibly constant throughout the Isthmus, the coolest and hottest hours of the day occur later near the Pacific coast than in the interior; and that during the dry season the daily range is much greater, and the hours of extreme heat are decidedly later, than in the season of rains. In the table asterisks indicate points of maxima and minima.

TABLE III. FIVE-YEAR HOURLY VARIATIONS IN TEMPERATURE, IN DEGREES FAH.

Hour.	DRY SEASON.		RAINY SEASON.		EXTREME MONTHS.			
	Alhajuela.	La Boca.	Alhajuela.	La Boca.	Alhajuela.		La Boca.	
					March.	Nov.	March.	Nov.
1 A. M.....	74.9	78.2	75.4	77.6	74.4	75.3	78.4	76.4
2 "	74.4	77.5	75.2	77.1	73.7	75.1	77.5	76.0
3 "	73.8	76.8	74.7	76.6	73.2	74.8	76.8	75.5
4 "	73.4	76.2	74.4	76.2	72.9	74.5	76.1	75.2
5 "	73.0	75.7	74.3	75.9	72.5	74.3	75.5	74.9
6 "	72.8*	75.2	74.2*	75.5	72.3*	74.2*	74.9	74.6
7 "	74.3	74.6*	75.4	75.2*	73.8	74.9	74.2*	74.3*
8 "	78.8	74.7	76.3	75.2*	78.7	77.1	74.5	74.6
9 "	83.4	76.3	81.5	77.1	84.4	80.3	76.1	75.7
10 "	85.9	78.5	83.8	78.8	87.5	82.7	78.6	77.3
11 "	87.4	80.6	85.2	79.2	89.1	84.2	80.9	78.8
Noon	82.2	82.0	85.7*	81.6	90.0	84.7*	82.5	79.9
1 P. M.....	88.3	83.4	85.4	82.6	90.4*	84.4	84.6	80.9
2 "	88.5*	84.5	84.5	83.2*	90.2	83.7	85.2	81.5
3 "	87.9	85.3	83.6	83.2*	89.6	82.7	85.9	81.6*
4 "	86.9	85.5*	82.5	82.8	88.3	81.6	86.1*	81.5
5 "	85.1	85.4	81.4	82.4	86.4	80.5	86.1*	80.9
6 "	83.1	85.1	80.0	81.8	84.1	79.2	85.9	80.4
7 "	81.1	84.3	79.0	81.4	81.8	78.3	85.1	79.8
8 "	79.7	83.4	78.0	80.8	80.2	77.5	84.0	79.3
9 "	78.2	82.2	77.3	80.1	78.7	77.0	82.6	78.6
10 "	77.3	81.2	76.8	79.6	77.4	76.4	81.6	78.0
11 "	76.4	80.1	76.2	78.8	76.3	76.0	80.4	77.4
Midnight ...	75.7	79.7	75.7	78.2	75.4	75.6	79.3	76.9
Means	80.4	80.3	79.0	79.2	80.9	78.5	80.5	77.9
Maxima	98.2	95.4	96.6	91.0	97.4	91.9	86.9	88.2
Minima	63.8	68.0	66.0	68.0	63.8	69.3	68.0	69.1

The health question, during construction, is one of the important elements of the canal problem. While no one will claim that the climate of the Isthmus is salubrious, it is certain that much wild exaggeration has been circulated, in great part founded on the experience of ill-acclimated laborers engaged in excavating surface soil for the

railroad or for the canal. Fortunately most of the work on the latter has now reached a level below the poisonous emanations of decaying organic matter, and during recent years the percentage of disease and mortality has not exceeded that on large works in any country. The actual facts are set forth in the following table prepared from his official records by Dr. Lacroisade, for many years the medical director of the fine Company Hospital situated on the heights above the city of Panama. He insists that the disease most to be dreaded, yellow fever, is not endemic on the Isthmus and, as in the Southern States, may be excluded by proper precautionary measures. The table itself is encouraging, since the mean percentages in the three epochs show nearly constant values for the diseases of Europe, and a great reduction for diseases due to the climate, under the improved conditions of the later work.

TABLE IV. OFFICIAL HEALTH STATISTICS OF THE PANAMA CANAL.

Years.	PERCENTAGE OF DISEASE. Effective Force Employed.	Diseases of Europe.	Diseases Due to Climate.	Total.	PERCENTAGE OF MORTALITY. Diseases of Europe.	Diseases Due to Climate.	Total.
			OLD COMPANY.				
1881	928	21.02	42.03	63.04	1.41	4.74	6.68
1882	1,910	18.85	47.64	66.69	3.21	4.39	6.60
1883	6,267	23.24	42.62	65.86	3.20	4.46	6.66
1884	17,615	27.58	36.95	64.57	2.58	4.08	6.66
1885	15,215	11.93	49.14	61.07	1.73	3.73	5.52
1886	14,935	14.01	43.88	57.89	1.67	3.43	5.10
1887	16,217	21.83	39.25	61.07	3.22	3.99	6.21
1888	13,725	12.17	40.46	52.63	1.81	2.54	4.35
Means ..	10,854	18.83	42.75	62.58	3.05	3.92	5.97
			RECEIVER.				
1889	1,826	.....	.....	.....	....	....	....
1890	about 800.	.....	.....	.....	....	....	....
1891		.....	.....	.....	....	....	....
1892		.....	.....	.....	....	....	....
1893		.....	.....	.....	....	....	....
1894		.....	.....	.....	....	....	....
Means ..	971	.....	.....	49.68	....	....	2.88
			NEW COMPANY.				
1895	1,225	.....	.....	49.96	2.05	0.89	2.94
1896	3,715	.....	.....	39.91	2.08	0.84	2.92
1897	3,980	.....	.....	51.85	1.99	1.00	2.99
1898	3,400	28.26	13.65	41.91	1.76	0.27	2.03
1899	2,500	19.76	5.84	25.60	2.24	0.12	2.36
1900	2,000	17.05	8.50	25.55	3.00	0.25	3.25
1901	2,000	18.60	6.85	25.45	1.55	0.20	1.75
Means ..	2,703	20.92	8.71	37.17	2.10	0.51	2.61

The relative danger of earthquake disturbances on the different routes suggested for an Isthmian canal has naturally attracted the attention of engineers. To secure definite information as to this matter two delicate seismographs were established at the Company Hospital near Panama in September, 1900, and the record is continuous since that date, covering forty-four months. The register shows seven slight tremors, four light shocks, and no severe shocks, the total duration of the disturbances being less than half a minute. It fortunately happened that the well equipped Institute Fisico-Geografico, under the direction of Monsieur Pittier, situated at San Jose de Costa Rica about sixty miles from the projected locks of the eastern division of the Nicaragua Canal route, instituted a similar series of observations in January, 1901, the results of which have been published in the U. S. Monthly Weather Review. These simultaneous records now cover thirty-seven of the forty-four months registered at Panama, and show in them forty-one slight tremors, eighty-nine light shocks, and thirty-seven severe shocks, the total duration of the earth motion being more than sixteen minutes. The fact that the Isthmus of Panama is much more stable than the region traversed by the rival route, and hence is less exposed to dangers from earthquakes, is thus established beyond cavil.

It only remains to bring up to date the records concerning the Chagres river contained in THE ENGINEERING MAGAZINE for December, 1902. The observations of the New Canal Company have continued without interruption to the end of April, 1904; and the following figures complete Table I of the Appendix.*

NUMBER AND DURATION OF RISES AT GAMBOA EXCEEDING 10 FEET ABOVE THE LOW-WATER STAGE, THE GREATEST HEIGHT IN FEET ABOVE LOW WATER, AND THE LOCAL RAINFALL IN INCHES.

Month.	Rises.	Hours.	Feet.	Rain.
1902.				
Sept. ..	0	0	7.3	8.9
Oct. ...	2	15	16.4	12.9
Nov. ..	1	7	11.8	14.4
Dec. ...	0	0	6.1	2.2
1903.				
Jan. ...	0	0	2.4	0.7
Feb. ...	0	0	4.1	0.1
Mar. ..	0	0	0.6	0.3
Apl. ...	0	0	1.3	0.4
May ..	0	0	5.7	11.1
June ..	1	2	10.1	11.1
1903.				
July ...	1	14	18.7	13.5
Aug. ..	1	7	16.1	12.9
Sept. ..	0	0	8.3	9.3
Oct. ...	0	0	9.0	14.2
Nov. ..	3	48	20.3	11.9
Dec. ..	6	23	13.0	13.9
1904.				
Jan. ...	1	7	14.0	3.4
Feb. ...	0	0	5.5	0.2
Mar. ..	0	0	2.3	1.9
Apl. ...	2	6	11.5	12.0

The rating-table formulae (page 339*) were revised in last September to include all gaugings to date, aggregating 1 599 at Alha-

* THE ENGINEERING MAGAZINE, December, 1902.

juela, 2,147 at Gamboa and 1,854 at Bohio. The only changes found desirable were to substitute 6 for 8 in the Alhajuela formula, and 24 for 26 in that for Gamboa; but large freshets at Alhajuela had occurred, affording the desired data for a freshet formula at that locality, which is the following.

$$Q = -7 + 110\,(C-28) + 40\,(C-28)^2 - 1.8\,(C-28)^3$$

The analysis of the ratio between downfall and drainage, discussed on pages 355 to 362*, has been extended to include all later records, and the results appear in full in the Monthly Weather Review for February, 1904. The conclusion that ground water constitutes a very important part of the volume of the Chagres is amply confirmed. In round numbers it appears that of the entire rainfall in the basin about one-third evaporates, another third flows off directly by the bed of the river, and the residue, after a retardation of perhaps three months by its passage through the soil, ultimately reaches the river as ground water. During the dry months it supplies much the larger part of the flow. In fine, the conditions of this tropical basin as compared with those existing in the northeastern portion of the United States, indicate per square mile about 2.5 times the rainfall, 3.3 times the outflow, and 1.5 times the evaporation.

The matter of the water supply of the canal in the dry season, discussed on pages 362 to 366*, is so important that it has long seemed desirable to make a further and exhaustive analysis of all the available data, with a view to determining as accurately as possible the ratio between the volumes passing Alhajuela, Gamboa, and Bohio in different seasons of the year. Indeed, this has only been deferred in order to accumulate sufficient data, which has now been secured. There are available for comparison 79 measured monthly discharges at Alhajuela, 169 at Gamboa, and 137 at Bohio. The percentages resulting from the analysis, with their probable errors, the latter in this case representing the effect of variations in the location of rainfall at the different dates, may be stated as follows:

The volume passing Alhajuela is 82 ± 2.1 per cent. of that passing Gamboa in the dry season, 76 ± 1.4 per cent. in the rainy season, and 79 ± 1.0 per cent. annually.

The volume passing Alhajuela is 71 ± 2.7 per cent. of that passing Bohio in the dry season, 51 ± 1.5 per cent. in the rainy season, and 55 ± 1.4 per cent. annually.

The volume passing Gamboa is 86 ± 2.0 per cent. of that passing

* THE ENGINEERING MAGAZINE, December, 1902.

Bohio in the dry season, 65 ± 1.6 per cent. in the rainy season, and 68± 1.4 per cent. annually.

Comparing these percentages with those given on page 362 of the Magazine it will be noted that no important differences appear between them and those heretofore provisionally used, and that the small probable errors justify what has not been attempted before, to wit the supplying of the lacking monthly discharges at Alhajuela by transferring to that station those measured at Gamboa, using the percentage corresponding to the season. The distance between the two localities is only about eleven miles by river. By this process is secured a trustworthy continuous series of monthly discharges at Alhajuela for fifteen consecutive dry seasons and for fourteen consecutive rainy seasons. The figures appear on the following page.

The possession of these figures, representing all that it is desirable to know respecting the monthly flow of the river during more than fourteen years, renders superfluous the tentative analyses contained in the tables on pages 363 and 364 of the Magazine. The mean trimonthly discharge during February, March and April is shown to be at Alhajuela 965 cubic feet per second, at Gamboa 1,176 cubic feet, and at Bohio 1,371 cubic feet, the corresponding absolute minima being 530, 530, and 753 cubic feet,—the later occurring in the year 1901. So also in regard to the total annual volume which the river can supply, an important consideration when the annual traffic shall approach the maximum that can be mechanically accommodated (about 23,000,000 tons) this table furnishes the desired information. The average volume at Alhajuela is 2,424 cubic feet per second, at Gamboa 3,164 cubic feet, and at Bohio 4,798 cubic feet, the corresponding minima being 1,837 cubic feet, 2,345 cubic feet, and 3,384 cubic feet,—the latter noted at Alhajuela and Gamboa in the year 1900, and at Bohio in 1899. These results, as appears from the discussion in the Magazine do not differ materially from those estimated long ago by the engineers of the New Canal Company.

The river is marvelously adapted to the needs of the Canal, and with a proper system of regulation there will never be a shortage of water or annoying currents in the route traversed by shipping. Now that we have inherited the work it behooves American engineers to recognize that these facts have been established by most thorough and painstaking investigations conducted for many years under difficulties that would have discouraged engineers less able and devoted than Monsieur Maurice Hutin, the director general, and Monsieur Louis Choron, the director of investigations and of construction, and their able assistants on the Isthmus.

MEAN MONTHLY DISCHARGE OF THE CHAGRES IN CUBIC FEET PER SECOND.

AT ALHAJUELA.

Month.	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	Means.
Jan.	2190*	**1554**	**1165**	**1731**	**2825**	**2684**	2437	**1342**	**3284**	**2684**	1589	989	4238	1130	3002	2190
Feb.	**1095**	777	918	**1660**	**1342**	**1236**	1059	918	**1236**	777	812	671	1271	848	1589	1081
Mar.	918	494	812	**1024**	777	742	600	424	600	777	530	459	812	494	954	695
Apl.	**1024**	424	**1695**	**2402**	600	918	1271	563	**1519**	883	565	459	1695	565	2190	1118
May	**3249**	**2649**	**4203**	**2331**	**1059**	1483	2543	**2507**	**1872**	1589	1342	1554	2119*	1377	....	2134
June	**4061**	**1801**	**2649**	**2437**	**1695**	2048	2225	**1801**	**2190**	2154	1554	1731	2190	1942	....	2177
July	**4097**	**2861**	**5651**	**2719**	**3390**	1801	**2225**	**2861**	**3143**	2225	2190	1978	2119	3108	....	2883
Aug.	**4309**	**2119**	**4626**	**3602**	**2967**	2543	2145	**3108**	**3143**	3284	2825	2437	2331	3178	....	3044
Sept.	**5191**	**2296**	**3320**	**2967**	**3390**	1907	2154	**2931**	**1907**	2402	2154	2931	2366	2790	....	2765
Oct.	**4909**	**3390**	**4521**	**2896**	**3567**	3638	2048	**2931**	**2649**	2649	3214	2755	3214	2755	....	3224
Nov.	**3002**	**5686**	**5509**	**3461**	**4980**	2543	2472	**3390**	**3885**	2931	2967	4768	3143	4909	....	3832
Dec.	**4485**	**3885**	**4627**	**6110**	**8088**	3920	**3885**	**3532**	**1731**	2260	2296	3037	1836	5474	....	3940
Year	3211	2328	3308	2778	2890	2122	2089	2192	2263	2051	1837	1981	2278	2381	....	2424
3 dry	1012	565	1142	1695	906	965	977	635	1118	812	636	530	1259	636	1578	965
Rainy	3944	2917	4030	3139	3551	2507	2459	2711	2645	2464	2237	2453	2617	2963	....	2910

AT GAMBOA.

Jan.	2755*	2048	1519	2296	3708	3532	2225	1766	4309	3496	1695	1024	5227	1625	4132	2757
Feb.	1342	954	1095	2013	1625	1483	1130	1130	1483	954	812	671	1589	918	2402	1307
Mar.	1045	600	989	1236	954	1095	636	494	1024	954	530	459	1024	706	1695	896
Apl.	1059	530	2048	2931	742	1130	1342	671	1836	1059	565	459	1942	706	2861	1325
May	4273	3461	5509	3037	1377	3461	4450	3284	2472	1907	1342	1766	2896*	1519	....	2904
June	5333	2366	3496	3214	2225	3178	4132	2366	2861	2472	1942	2048	2896	2154	....	2906
July	5403	3779	7416	3567	4450	3073	2931	3779	4238	2825	3355	2190	3002	3320	....	3809
Aug.	5686	2790	6075	4732	3885	4061	2331	4097	4132	4238	3567	2861	2790	4344	....	3971
Sept.	6816	3037	4379	3885	4450	3390	2719	3850	2543	3178	3073	3638	2931	4697	....	3756
Oct.	6498	4450	5933	3744	4697	4944	2684	3850	3461	3390	4520	3702	4415	3956	....	4303
Nov.	3956	7487	7240	4556	6534	3532	**3249**	4450	5192	3744	4061	6746	4732	5721	....	5086
Dec.	5898	5121	6075	8052	10630	3779	5121	4626	2296	2649	2684	3143	2190	7028	....	4949
Year	4172	3052	4314	3605	3773	3055	2750	2864	2987	2572	2345	2391	2969	3058	....	3164
3 dry	1149	695	1377	2060	1107	1236	1036	765	1448	989	636	530	1518	777	2319	1176
Rainy	5180	3838	5294	4120	4662	3661	3317	3563	3500	3100	2915	3013	3453	3818	....	3827

AT BOHIO.

Jan.	4132*	2684	**2331**	**3532**	7063	4556	4732	2048	5651	3850	2119	1483	11231	1625	4944	4132
Feb.	**1554**	1377	**1271**	**2331**	1801	1377	1554	1589	1695	1731	1059	989	2084	1024	2331	1585
Mar.	**1271**	600	**1165**	**1448**	1095	1059	1695	706	1095	989	742	706	1271	636	1413	1009
Apl.	**1236**	600	**2366**	**3426**	777	1059	1695	883	2013	1095	706	565	2154	565	3638	1519
May	**6569**	5333	**8476**	**4662**	3355	4167	4944	7982	2684	2048	1625	2296	4273*	1519	....	4281
June	**8193**	3214	**5439**	4944	4273	4309	4203	4203	3355	3143	2861	2790	3178	2543	....	4046
July	**8300**	4803	**11407**	7628	6216	4591	3143	5121	6569	3956	5615	3178	3037	4026	....	5542
Aug.	**8759**	4521	**9359**	10772	6498	6922	3496	7275	5298	5721	5262	4309	3390	5474	....	6218
Sept.	**10489**	**4344**	**6746**	7664	7452	5792	5933	6887	3214	4238	4768	5792	3920	5686	....	5923
Oct.	**9995**	**6851**	**9112**	8582	9359	6922	6357	7487	5050	4944	6993	6322	5933	5580	....	7100
Nov.	**6075**	**11513**	**11125**	11443	12714	6075	7593	6957	7840	5296	6605	13244	6675	8335	....	8678
Dec.	**9076**	**7876**	**9359**	18541	12573	6957	6039	6816	2861	3602	3744	4591	3002	10489	....	7538
Year	6304	4476	6513	7081	6098	4482	4216	4830	3944	3384	3509	3855	4179	3958	....	4798
3 dry	1354	859	1601	2402	1224	1165	1377	1059	1601	1272	836	753	1836	742	2461	1371
Rainy	7954	5682	8150	8641	7723	5588	5160	6086	4725	4089	4400	4889	4960	5031	....	5940

* Interpolation, means of all months of same name at station.

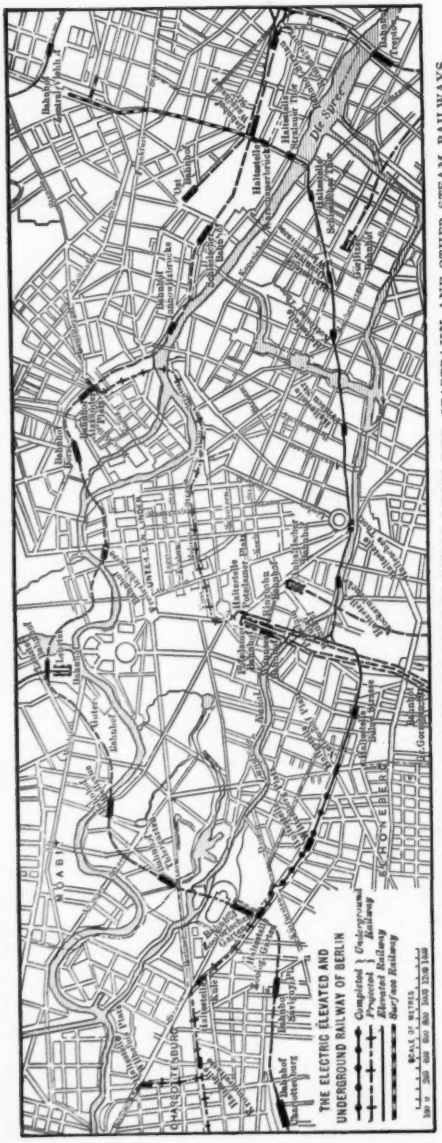
This table replaces Table II of the Appendix, page 368, THE ENGINEERING MAGAZINE for December, 1902. Figures marked by heavier faced type are transferred from adjacent station by the use of the percentages given on pages 728 and 729.

THE BERLIN COMBINED ELEVATED AND UNDERGROUND RAILWAY.

By Paul Möller.

The following article is the second of a series of three, presented as especially pertinent to the approaching opening of one of the most important rapid-transit lines in the world—the New York underground. The first of the series was published in this magazine in June last, and described the latest of the London tubes. The third, which will follow in a later number, will describe the New York underground itself.—THE EDITORS.

THE map of greater Berlin shows a larger extension from east to west than in other directions, the expansion following the course of the Spree river, and necessarily the main stream of traffic moves on the same line. Besides the tramways, which for several years have all been operated by electric power, the Metropolitan Railway (Stadtbahn), built 22 years ago on masonry arches and still using steam locomotives, was at the disposition of the public. The Metropolitan connects Rummelsburg, a suburb in the east, and the city of Charlottenburg, the neighbouring city in the west of the capital, both being practically parts of greater Berlin. The line is not straight from east to west, making a curve to the north; consequently the southern quarters were for a long period without a rapid-transit connection, and the new Combined Elevated and Underground Railway was designed to supply this want. (See the map on the next page.)


THE ELECTRIC ELEVATED AND UNDERGROUND RAILWAY OF BERLIN
Completed
Projected
Underground Railway
Elevated Railway
Surface Railway
Scale of Metres
0 250 500 750 1000 1250 1500
CHARLOTTENBURG
SCHÖNEBERG
Bahnhof Zoologischer Garten
Bahnhof Nollendorfplatz
Bahnhof Wittenbergplatz
Bahnhof Gleisdreieck
Bahnhof Potsdamer Platz
Bahnhof Hallesches Thor
Bahnhof Möckernbrücke
Bahnhof Stadtbahn
Bahnhof Börse
Bahnhof Jannowitzbrücke
Bahnhof Schlesischer Thor
Bahnhof Warschauer Brücke
Bahnhof Ostbahnhof
Bahnhof Frankfurter Allee
Bahnhof Zentral Viehhof
Bahnhof Schönhauser Allee
Bahnhof Gesundbrunnen
Bahnhof Stettiner
Bahnhof Nordbahnhof
Bahnhof Hamburger
Bahnhof Lehrter
Bahnhof Moabit
Bahnhof Charlottenburg
Bahnhof Westend
Bahnhof Halensee
Bahnhof Grunewald
Bahnhof Schlachtensee
Bahnhof Steglitz
Bahnhof Südende
Bahnhof Lichterfelde
Bahnhof Friedenau
Bahnhof Wilmersdorf
Bahnhof Schmargendorf
Bahnhof Grunewald
Bahnhof Wannsee
Bahnhof Zehlendorf
Bahnhof Dahlem
Bahnhof Grunewald
Bahnhof Halensee
Bahnhof Westend
Bahnhof Charlottenburg
Bahnhof Moabit
Bahnhof Lehrter
Bahnhof Hamburger
Bahnhof Stettiner
Bahnhof Nordbahnhof
Bahnhof Gesundbrunnen
Bahnhof Schönhauser Allee
Bahnhof Zentral Viehhof
Bahnhof Frankfurter Allee
Bahnhof Ostbahnhof
Bahnhof Warschauer Brücke
Bahnhof Schlesischer Thor
Bahnhof Hallesches Thor
Bahnhof Potsdamer Platz
Bahnhof Gleisdreieck
Bahnhof Möckernbrücke
Bahnhof Stadtbahn
Bahnhof Börse
Bahnhof Jannowitzbrücke

that the cost of one kilometre of the line was on the average about 3,000,000 marks, while the Paris Metropolitan cost 3,500,000 and the London Central Railway 7,500,000 marks per kilometre.

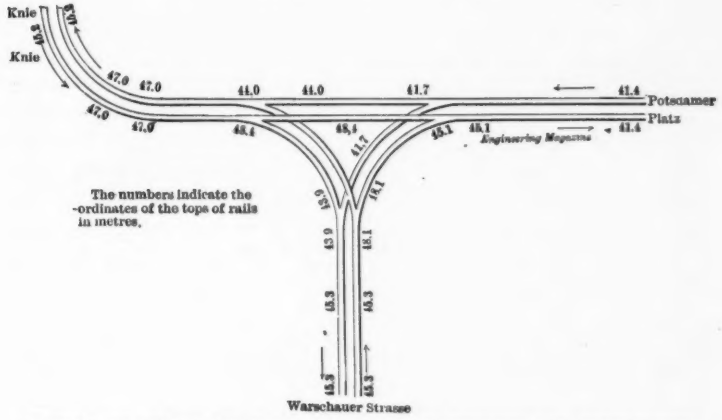


DIAGRAM OF TRIANGULAR INTERSECTION, BERLIN ELEVATED AND UNDERGROUND RAILWAY.

From the Zeitschrift des Vereines Deutscher Ingenieure.

The standard gauge was adopted in order to make it possible to haul regular railway cars if desired, and the line is double tracked throughout. It runs, as the name implies, partly overhead and partly underground. On the eastern division, where most of the streets touched by the line have a central promenade and a width of 31 to 52 metres, a steel structure could be easily built; one section utilises a small strip of 7 metres between the public street and a ship canal. But where the branch line of the new railroad ends, near the Potsdamer Platz, the space was too small for a steel structure, and in some streets of the western division—the quarter of the rich—though broad enough, the landlords and the parish of the magnificent "Kaiser Wilhelm Gedächtnis" church strongly opposed the construction of an elevated road, claiming that the appearance of the city would be spoiled. So it became a necessity to conduct the line here underground and to join these parts with the elevated division by inclines, of which the sharpest has a grade of 1 in 32, as it was thought that no other means of lifting and lowering the trains would be fast and safe enough for a rapid transit. However it is worth noting that the inclines have never caused the least trouble. The scheme of inclines adopted, it was necessary to build the tunnel as near as possible below the street level in order to have only a small difference

of height between the elevated and the underground lines. Another and not less important reason for this location of the tunnel was that the soil of Berlin consists mostly of quick-sand and the ground-water level is very high.

The most interesting construction of the road is the so-called "Gleisdreieck," a triangular junction between the main line and the above-mentioned branch leading to the Potsdamer Platz. The idea was to join the three different arms without any crossing of tracks on the same level, which would be too dangerous for a rapid-transit road. The problem was solved in this way, that one of the tracks intersecting another rises to such a height that it can be conducted over the lower track on an independent level. To get the required difference of levels grades of 1 in 38 were necessary. The sketch on the preceding page shows the crossings.

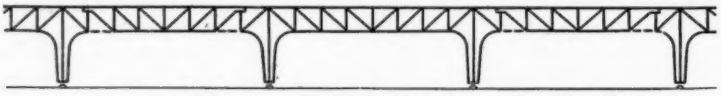


DIAGRAM OF SUPERSTRUCTURE CONSTRUCTION, BERLIN ELEVATED RAILWAY.

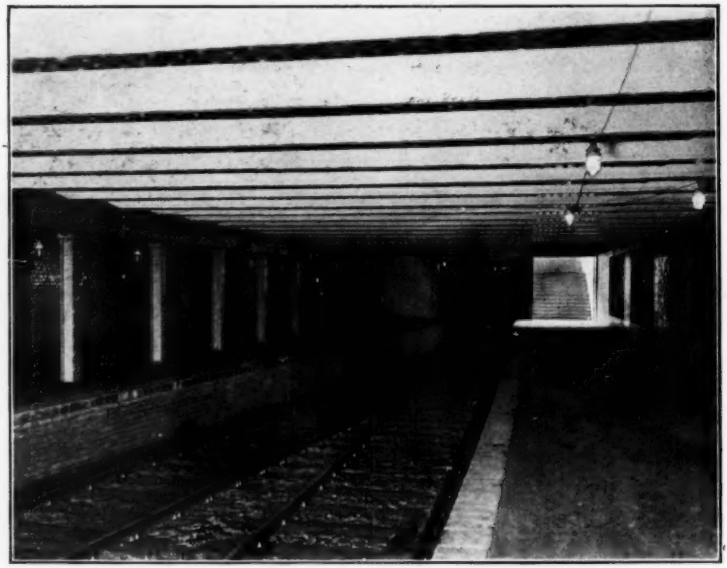
As the triangular junction is built within the boundary of the State railway and is removed from the city streets, the structure could be of masonry. But nearly all other viaducts, i. e., about 7,300 metres of the whole line, are constructed of steel. Various types of girders and pillars are used, but the most interesting seems to be a kind of cantilever construction consisting of a portal superstructure with projecting arms of which the extreme points are connected by a girder. The principle in designing the steel viaducts was that the street area obstructed by pillars or foundations should be a minimum. Besides, it was argued that the appearance should be attractive from an aesthetic standpoint, and the Siemens & Halske Co. charged some well-known architects with this task. In fact, the greater part of the structure in this respect is so great a success that the United States Consul General, Mr. Frank H. Mason, said in one of his consular reports: "The one respect in which the German constructors leave their American colleagues far behind, and offer an object lesson which our countrymen cannot study too soon or too thoroughly, is in the artistic beauty, the architectural charm and sense of fitness, which they have imparted to the stations, the bridges and even to the ordinary overhead viaduct sections of the new road."

Another problem was not so thoroughly solved, i. e., the suppression of the noise caused by passing trains. On the eastern division the

THE TRIANGULAR INTERSECTION.

UNDERNEATH THE VIADUCT, ON BÜLOW STRASSE.

A TYPICAL STATION ON THE OVERHEAD PORTION OF THE LINE.



STATION PLATFORMS ON THE UNDERGROUND PORTION OF THE LINE.

troughs of sheet-iron forming connection of the cross girders are filled with concrete and gravel, while the cross sleepers are fixed directly on the girders. On the western part of the sleepers are bedded in gravel, and the latter type damps the noise far the better.

In constructing the tunnel it was a necessity to restrict the dimensions so far as possible, the reasons being the same as for building it close under the street level. Therefore the cross section is 6.24 metres wide and 3.3 metres high, measured from top of rails. At the stations the width is augmented to 12.64 metres, so that on each

THE APPROACH TO THE UNDERGROUND SECTION, SHOWING THE CHANGE IN POSITION OF THIRD RAIL.

side of the tracks a platform 3.5 metres wide might be disposed—a proportion which seems somewhat small if traffic is great. The bottom and the side walls of the tunnel are built of rammed concrete. The ceiling is supported by the walls and by iron columns standing in the middle between the two tracks, and consists of concrete arches spanned between I-beams. The path for the supervision of the line is between the two tracks, where the guards may find a hold at the columns, while on the elevated part two paths are built outside the tracks. The whole body of the tunnel is covered by a layer of asphalt-board (*asphaltpappe*) preventing both ground and surface water

from entering. Besides this a small gutter is left in the middle of each track in the bottom. The tunnel was built in open cuts, and the ground-water level was lowered during construction by pumping.

For the permanent way two different types of rail are used; on the eastern division, where the sleepers are set on the cross girders of the steel structure, it was necessary to choose a strong profile because of the spacing of the cross girders being 1.5 metres apart. Therefore the rails are 180 millimetres high and weigh 42.7 kilos per metre. On the rest of the line, where the sleepers, embedded in gravel, are only 0.71 metres distant from each other, the constructors restrict-

OBERBAUMBRÜCKE AND THE STRALAUER GATE STATION OF THE BERLIN ELEVATED AND UNDERGROUND RAILWAY.

ed themselves to a rail of 115 millimetres height and 25.6 kilos per metre weight. The rails are not set under an angle of 1 to 20, as usual, but in a vertical position, as by the use of electric motors and bogie trucks the oscillating movements of the cars are small, and hence the tendency of the rails to tilt is greatly diminished. For the same reason the tyres have a cylindrical rim. In fact, the movement of the cars is very smooth, though the rails are not extremely strong, and that even in curves of which the sharpest has a radius of 80 metres.

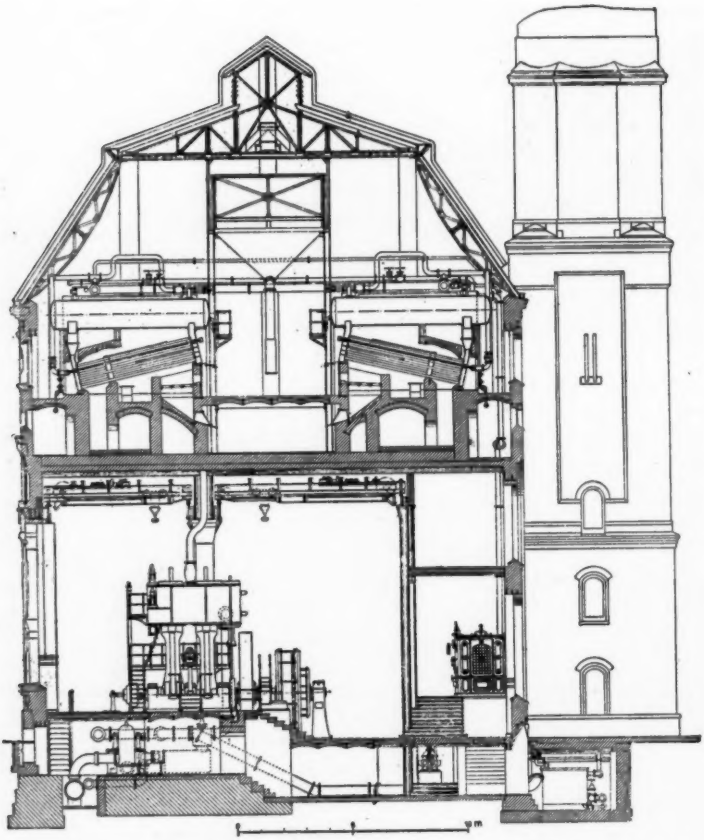
The motive power is supplied by continuous current of 750 volts at the generators and is distributed over the line by means of flat copper bars supported by porcelain insulators. For feeding the motors the third-rail system has been adopted, common rails on vulcanite insulators being used. On the elevated line the contact rails are laid be-

THE RAILWAY OCCUPYING THE STRIP BETWEEN ROADWAY AND RIVER.

tween the two tracks and are protected by wooden guards; on the underground line they are disposed outside the tracks near the side walls, and are usually unprotected. This difference of construction will be explained by the fact that on the former line the foot-path is outside, on the latter inside, the two tracks. For lighting the stations and the tunnel special copper wires are disposed.

The power station is situated near the Spree River and close to the triangular junction, the centre of the need of power. The building, several stories high, contains in the cellar the condensers and pumps, in the first story the steam-engines and generators, above that the chimney-flues and the channels for removal of ashes, and in the upper

THE STATION AT SCHLEISCHES GATE.



ELEVATION OF POWER HOUSE, BERLIN ELEVATED AND UNDERGROUND RAILWAY.

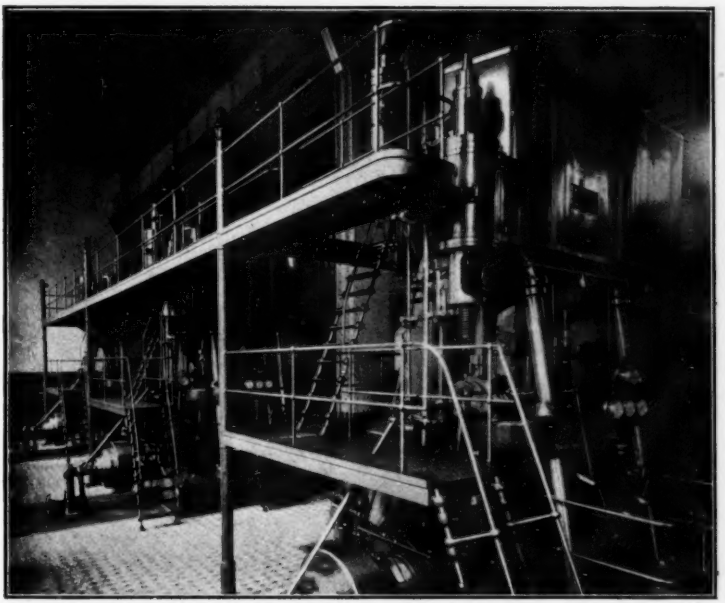
story the boilers. The coal is carried from the yard to the bins under the roof by a conveyor, and is supplied to the furnaces from a platform between the two rows of boilers. At the present time another conveyor is in course of construction, bringing the coal from shipboard through a tunnel underneath the public street to the yard.

There are six water-tube boilers of the Gehre type constructed for a pressure of 10 atmospheres and furnished with superheaters allowing a steam temperature of 225 degrees Celsius. The engines are of the upright compound type, and at present there are set three engines of 900 to 1,200 horse power and two of 1,200 to 1,500 horse power. They are directly coupled with Siemens & Halske shunt-wound gen-

erators of 750 volts. A storage battery of 1,000 ampere-hours capacity is used for equalising sudden changes of current.

The trains are composed generally of three cars, but during the hours of greater traffic of four. Besides this, in summer time two-car trains are run sometimes. The car-bodies are 12 metres long and 2.36 metres wide, and are supported by two 2-axle bogie trucks, each being able to carry two motors, but at present there are only three for each car, of 60 horse power normal capacity each, which are sufficient for the length of trains now used. During the ordinary run the motors are connected in series, while in starting they work in parallel, so that the acceleration is equal to 0.7 metres per second, this high figure being necessary on account of the short distance between stations. As a rule the first and the last car of a train are furnished with motors, and the maximum speed attained is 50 kilometres per hour. The cars have air brakes, the air pump and the air tank being underneath the car body between the trucks. The pump is driven by a small electric motor set in the driver's box. In case of danger a short-circuit brake or a hand brake may be used.

The cars have two side doors, one near each end, and on enter-



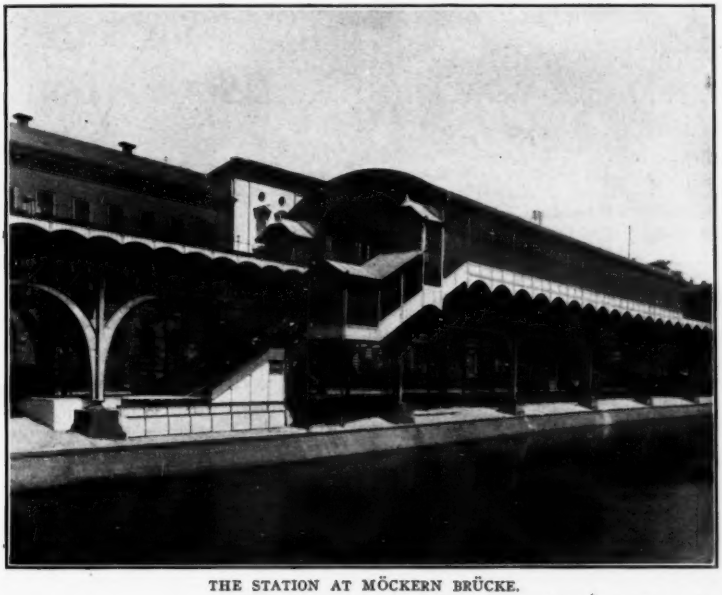
THE INTERIOR OF THE ENGINE ROOM IN THE POWER STATION.

ing the passengers pass through a vestibule open to the main room, where seats are arranged lengthwise and facing each other. On each side are fifteen seats of 51-centimetres width. More seats are in the vestibule, so that 35 to 40 passengers can be seated, but during the rush hours many persons are forced to stand, though the crowd is not so terrible as during certain hours on the New York elevated. The cars are lighted by twelve incandescent lamps, and are nicely furnished and very clean. An inconvenience is felt in summer time in that the windows cannot be opened on account of the narrow section of the tunnel. The result is that the air is sometimes insupportable, as the small openings underneath the roof are insufficient for ventilation; during winter the cars are well heated by electricity. The ordinary trains are composed of two third-class cars, one being a smoker, and between these two is one second-class car, divided by a door into two compartments, smoking and non-smoking. The third-class has wooden, the second upholstered seats.

For the safety of the railway a block-signalling system of the Siemens & Halske type has been established, and all stations, the power house, and the offices are connected by telephone.

The distance between the stations varies from 322 to 1,923 metres, and is on the average about 900 metres. The time consumed for running the trains over the three different lines is as follows:

A VIEW ALONG THE UNDERGROUND PART OF THE LINE, SHOWING THE OUTSIDE POWER-RAILS AND CENTER PATH.



THE STATION AT MÖCKERN BRÜCKE.

Line.	*Distance in Metres.*	*Time in Minutes.*
Warschauer Brücke—Möckern Brücke—Bülow Strasse —Knie	9,690	23
Warschauer Brücke—Möckern Brücke—Potsdamer Platz	6,330	15
Potsdamer Platz—Bülow Strasse—Knie	5,250	12

The platforms at the stations are separate for the two directions of travel, each platform having its own staircase. The level of the platforms is 0.8 metres above the top of rails, so that the passengers can enter the cars without any step.

The trains run on a headway of 2½ to 5 minutes, the average being 3.9 minutes. The present number of third-class cars is 73, of second-class cars 31. The fares are cheap—for a trip to the fourth station, in the third class, 10 pfennige (2½ cents); in the second class, 15 pfennige. To the seventh station; third class, 15 pfennige; second class, 20 pfennige; beyond that, 20 and 30 pfennige.

The new railway has become in a very short time an important factor in the public life of the German capital, and there can be no doubt that the projected new branches will be a success also. The most important project is the junction of the Potsdamer Platz with the Alexander Platz by a line which will cut through the heart of Berlin. All the new lines will be built as underground railways.

A NOTABLE MEXICAN HYDRO-ELECTRIC PLANT.

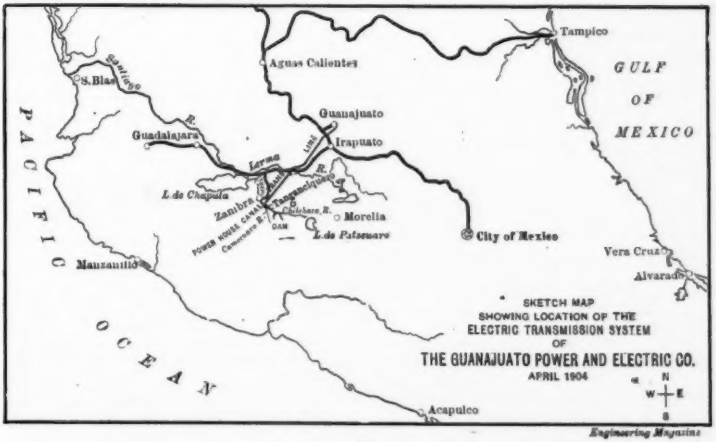
By Robert McF. Doble.

Mr. Doble's article is presented as a typical example of the opportunities which modern engineering developments afford for the exercise of professional talent, the use of machinery and appliances, and by their joint application, for the fuller and more profitable utilization of the natural resources of the earth.—THE EDITORS.

THE HEADWORKS OF THE GUANAJUATO POWER CANAL.

A VERY important addition to the rapidly increasing list of hydro-electric power developments and high-potential long-distance transmissions, has recently been completed in the States of Michoacan and Guanajuato, Republic of Mexico, at the location shown on the accompanying sketch map. Under a concession from the Department of Encouragement, Colonization, and Industry of the Republic of Mexico, The Guanajuato Power and Electric Company constructed a canal, pipe line, power-generating station, transmission line, substations, and distributing systems for developing and marketing the motive power of 8,000 litres (283 cubic feet) of water per second of the Duero River.

The water supply is derived principally from the numerous springs which issue from the porous volcanic rock at many points in the extensive watershed area. That the underground storage is large and reliable is demonstrated by the slightness of the variations in the volume discharged by the springs. The region drained by the Chilchota River is a series of fertile valleys, lying one above the other, having a total area estimated at 400 square miles and extending to the Continental Divide. It embraces many high mountains, some of which are timbered, and some lakes with no visible outlets. The elevation is from 5,000 to more than 12,000 feet above sea level. The Camecuaro River is fed entirely by the Camecuaro Springs. It is only about one



SKETCH MAP OF THE GUANAJUATO POWER TRANSMISSION.

mile long and has practically no drainage area. The Duero River is formed by the Chilchota and Camecuaro Rivers, at the confluence of which the diverting dam and head works of the canal have been constructed.

The masonry dam is built of volcanic rock, the interior being laid up with lime mortar and the exterior with Portland cement. It is a curved structure with a radius of 88.19 metres, the length of the crest being 80 metres. Its elevation is 1,662.40 metres above sea level. It is computed as a gravity dam for a maximum depth of 1.60 metres of water over the crest.

A heavy steel fender (page 746) securely braced against the masonry, protects the entrance to the canal from the drift brought down by the freshets during the rainy season. Water is admitted to the canal through four head gates (page 744) each with an opening 1.25 by 2.00 metres, at a maximum velocity of about 0.80 metres per second. These head gates run in an angle-iron frame set in the concrete, are made of wood heavily ironed, and are operated by means of a screw stem and a worm gear nut with ball bearings, which is turned by means of a hand crank operating a worm spindle with bronze thrust collars.

The canal is 6,650 metres long, of trapezoidal section, 4 metres wide on the bottom and 2.10 metres deep. The side slopes are 1 to 1 in soft earth, 0.5 to 1 in hard rock and 0.2 to 1 where the canal is lined with cement. Its slope is uniform 1 to 2,500. Its carrying

capacity is 283 cubic feet per second at a velocity of between two and three feet per second.

To provide for accurately measuring the volume of water allowed under the concession, a "rating flume" was constructed near the head works. It is about 100 feet of straight canal lined with Portland cement held in place by sheets of expanded metal. The top of the wall on the side toward the river is finished with an adjustable metal weir (see the opposite page) set so as to act as spillway when more than the proper volume of water is flowing. A short distance down stream the canal is widened and deepened, causing a reduction in the velocity of the flowing water to about one-third of the normal so that any sand may settle to the bottom. This settling basin (page 747)

THE HEAVY STEEL FENDER AT THE HEADWORKS.

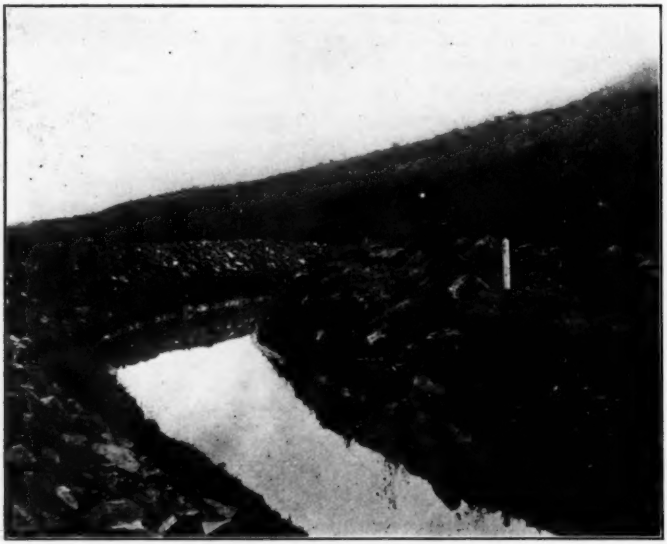
is provided with six valves, opening from its bottom into a culvert which leads out from under the canal to the river. These valves are of new and interesting design, consisting of a circular cast-iron opening 18 inches in diameter closed by means of a conical cast-iron bell, drawn point up into the opening from below and held there by means of a threaded stem and nut which rests upon two channel beams spanning the canal. By turning the nut the cast-iron bell may be lowered to open the valve and wash out the sand which has collected at the bottom. Immediately below the settling basin there is an adjustable submerged weir, shown quite plainly on the facing page. By means of

the head gates and by the adjustable lip at the rating flume in conjunction with the submerged weir, the quantity of water flowing in the canal may be closely regulated.

THE RATING FLUME, SHOWING THE ADJUSTABLE STEEL LIP.

From this point the greater portion of the canal is of the character shown on the next page. It meanders along the southerly side of the canyon, under a substantial masonry-arch road bridge 33 feet wide and 16 feet span, over a massive masonry aqueduct to a spillway, and thence to a second sand trap near the forebay. The spillway and second sand trap are located so as to make use of the Barranca de La Rojena as a waste-water way leading to the Duero River. A small storage reservoir is constructed alongside the canal at the forebay, having a capacity of more than 2,000 litres per second for four hours. At the entrance to the forebay the water passes over a measuring weir. On passing from the forebay

THE UPPER SAND TRAP AND THE ADJUSTABLE SUBMERGED WEIR.



THE WINDING CANAL.

to the penstock the water flows through a screen which removes all floating debris. (See page 750.)

The massive masonry penstock is strengthened by embedded iron hoops and is interesting because of its excellent hydraulic lines. The water, after passing through the screens and through four gates similar to those at the head works, enters two ellipsoidal masonry basins which gradually diminish in diameter toward the bottom, merging into the great oval taper sections which are the heads of the pipe lines (Page 751). This design causes a gradual acceleration in the velocity of the water and also prevents the formation of the whirling vortex which would draw in air.

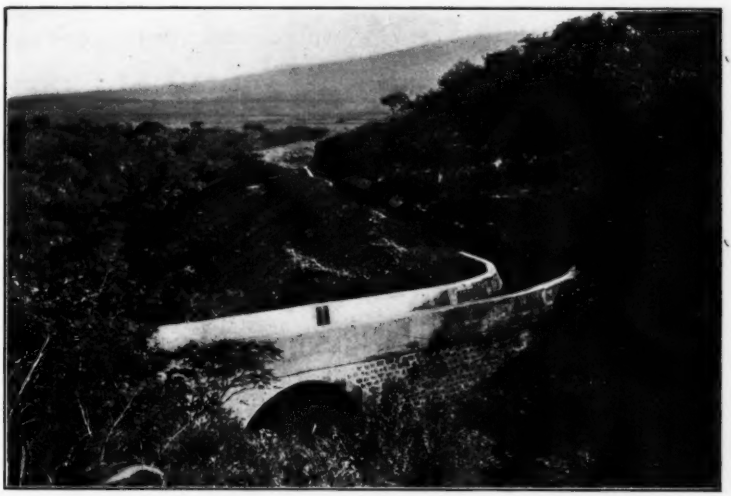
The pipe line is 3,300 feet long, with no lateral bends. It varies in diameter and thickness as shown in the following table, and was designed with a safety factor of five.

Inside Diameter of Pipe.	Thickness of Plate.	Approximate Length.
69 inches	5/16 inches	1,100 feet
63 "	3/8 "	1,000 "
63 "	7/16 "	100 "
57 "	7/16 "	350 "
57 "	1/2 "	350 "
57 "	9/16 "	200 "
57 "	5/8 "	200 "
Total		3,300 "

The decrease in the diameters of the pipe section causes an acceleration in the flow of the water as it descends. This also made possible the nesting of sections for shipment. The pipe was made up from steel plates, in sections 27½ feet long and weighing from 7,000 to 10,000 pounds each.

All seams were lapped and the longitudinal seams were designed so as to have at least 70 per cent. of the strength of the plate. These longitudinal seams were placed so that they are on top of the pipe and alternately opposite, with the calking edges up as shown on page 752. The longitudinal seams are double-riveted, the circular seams single-riveted. All the shop riveting was done by a large hydraulic riveter. The field riveting was done by hand by a gang of expert boiler makers sent to Mexico for that purpose. Two riveters, a helper, and a man at the forge to heat rivets could finish one circular seam in a day. When riveted the pipe was calked and an extra coat of preservative paint was applied. Each section of the pipe had on top, near its lower end, a hole through which the hot rivets were passed from the forge to the man inside. The hole was tapped and a plug screwed in after the joint was riveted (see page 752). Each section was plainly marked at the factory with letters indicating its position in the pipe line.

The common practice of laying pipes of this character on top of



THE MASSIVE MASONRY AQUEDUCT CARRYING THE POWER CANAL.

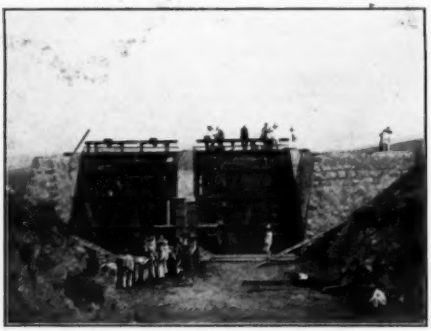
THE FOREBAY AND PENSTOCK.

the ground and supporting them on piers was not followed. A trench was dug, the bottom of which was graded on long tangents and with slight vertical angles. The pipe was laid in this trench, beginning with the section nearest the power house and riveting on section after section, working up hill. Bell holes were dug in the bottom of the trench so that the riveters might have room to swing their hammers. The back filling of the trench was done with great care, the earth being dampened and thoroughly tamped under and around the pipe. During the early morning hours, while the pipe was cool and at its minimum length, the top covering was completed.

On August 24th, 1903, the pipe was tested, and so well had the work been done that not a single leak was found, although there are over 70,000 rivets.

The pressure pipe terminates at the bottom of the hill in a branching cast-iron pipe leading through the south wall of the power house to the nozzles.

The power house (pages 753, 754,) has masonry walls built of native volcanic rock. The roof is of galvanized iron supported by steel roof trusses and lined with an anti-condensation lining. Its inside dimensions are, length 200 feet, width, 32 feet. The floor is of cement. A low wall separates a length of 40 feet at the easterly end of the building where the transformers are placed which portion is two feet lower than the main room and is provided with drains into the tail race. There



THE SCREEN AT THE PENSTOCK DURING CONSTRUCTION.

are two 10-ton hand-operated cranes which run the entire length of the building over both generator and transformer rooms. The erection of these cranes was an unusually simple matter. They were rolled into place from the surface of the ground, and subsequently constituted the basis of a movable platform upon which the roof trusses were carried to place, as shown on page 753.

The cast-iron branch pipes convey the water to heavy 30-inch gate valves equipped with by-passes. The nozzles are attached to the gate valves. These pipes are made of close-grained gray cast iron and have lip and recess flange joints with lead gaskets and are entirely buried in concrete.

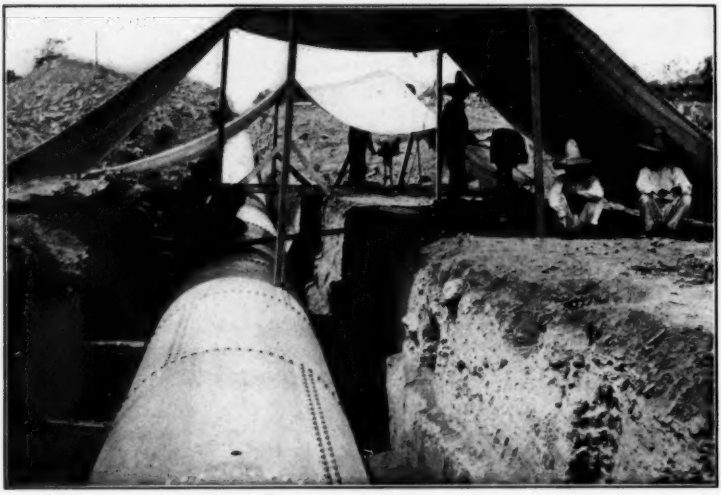
LOOKING OUT OF THE GREAT OVAL SECTION AT THE HEAD OF PIPE LINE NO. 2, DURING CONSTRUCTION OF THE PENSTOCK.

As shown in the plan, the nozzles are curved in form, making a 45-degree bend so as to bring the axis of the jet at right angles to the water-wheel shaft. Each nozzle is provided with a removable tip, of cold-blast charcoal iron, held in place by means of 14 7/8-inch Tobin-bronze studs with steel nuts. The nozzle is of the needle regulating type, having a core piece movable axially within it by means of which the annular area of the orifice is changed. The core piece is a Tobin-bronze stem with a phosphor-bronze bulb fitting into the nozzle tip. A continuation of the steam through a gland in the convex side of the nozzle casting is threaded, and, by means of a bevel-gear nut operated through a hand-wheel stand, the needle is moved in and out to adjust the quantity of water discharged by the nozzle, so that the maximum economy in the use of water may be attained.

This construction produces a solid jet of good form and of high efficiency over a wide range of discharge. Each nozzle is equipped with a deflecting hood, operated through a system of levers by a governor, for regulating the speed of the generating unit.

The water emerging from the nozzle tips in solid jets more than half a foot in diameter, at a velocity exceeding a mile and a half per minute, with a pressure of 138 pounds per square inch, is projected into the buckets of the water wheels. (Page 755.)

Each water wheel has fifteen huge buckets, more than two feet in width and weighing 254 pounds apiece, made of close-grained cold-



RIVETING UP PIPE IN THE TRENCH. THE HOLE FOR PASSING HOT RIVETS IS SEEN IN THE FOREGROUND.

blast charcoal iron. The buckets are accurately fitted to the rim of the cast-iron wheel centre and secured thereto by means of two fitted steel stud bolts. The entrance edges are sharpened, the hydraulic surfaces are ground smooth and painted, and each bucket is brought to a standard weight so as to obtain a dynamic balance. The cast-iron wheel centres are machine-finished all over, bored taper, key-seated, and secured onto the projecting ends of the generator shafts by means of a feather and a large bronze nut.

The solid carbon-steel shaft is 12 inches in diameter from the water wheels through the bearings, being enlarged to 16 inches diameter in the middle portion. The bearings are 36 inches in length by 12

SETTING UP THE ROOF TRUSSES WITH THE HELP OF THE TWO CRANES.

inches in diameter, of ring-oiling water-cooled type of special design. The generators are revolving-field, engine-type, 2,300 volt, 3-phase, 60-cycle, 200-revolution machines, rated at 1,250 kilowatts, but designed for a 25-per cent. continuous overload. Their characteristics,

THE INTERIOR OF THE POWER-GENERATING STATION.

GENERAL VIEW OF THE POWER-GENERATING STATION.

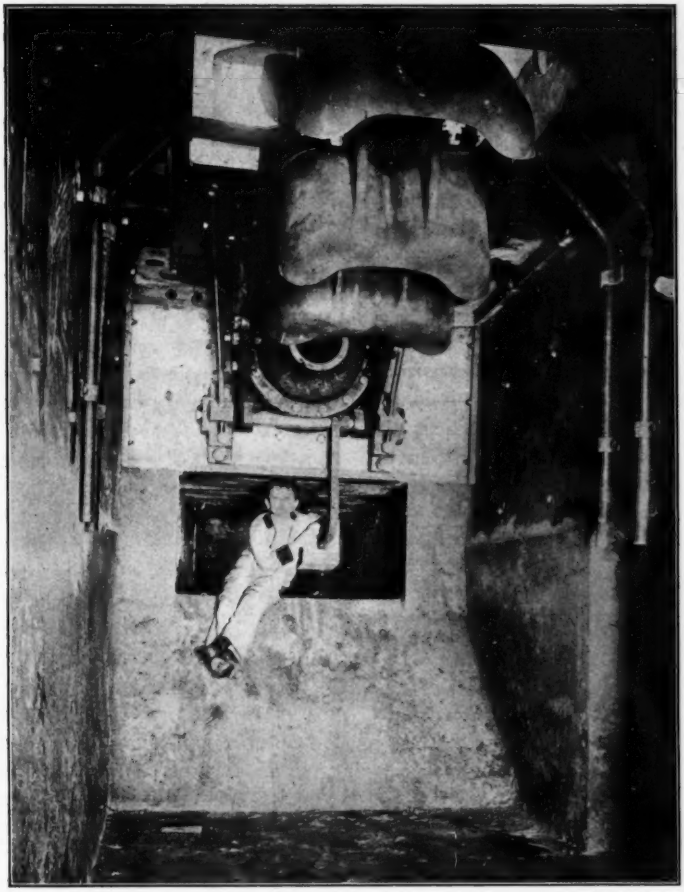
as determined by factory test, are as follows: Full load commercial efficiency, 95.77 per cent.; three-fourths load, 94.92 per cent.

Regulation at full load and 10 per cent. power factor is 4.4 per cent.; temperature rise of armature 21 degrees C. after 6 hours full-load operation.

The total weight of the revolving element, consisting of the field, the shaft, and the two water wheels, is about 50,000 pounds, carried on two bearings. The speed is regulated by means of a governor, operated by an oil-pressure system, actuating the deflecting hoods already described. The governors and the oil-pressure pumps are belted from the generator shaft.

The hydro-electric generating units above described are conspicuous by reason of their compactness and simplicity, there being only the stationary armature, the electric and hydraulic revolving elements mounted on the shaft, and two bearings. The 1,250-kilowatt unit occupies a floor space of only about 17 feet by 25 feet.

Continuous current for exciting the alternators is supplied by two 120-kilowatt 500-revolution self-contained hydro-electric units each of sufficient capacity to excite the four generators, so that one exciter is a spare. The exciter base is extended so as to receive the water-wheel housing. The water wheel is mounted on the extended end of the shaft overhanging the bearing. Water is supplied to the wheel through a hand-regulating needle

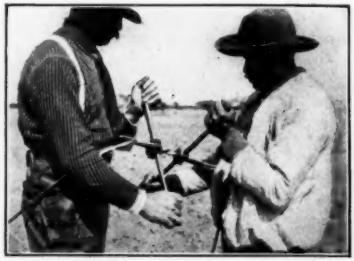


NOZZLE TIP, DEFLECTING HOOD, AND WATER-WHEEL BUCKETS.

nozzle, being conveyed from the main branch pipe. The current is conveyed from the machines to the switchboard, and thence to the step-up transformers, through lead-covered rubber-insulated copper cables laid in shallow covered ducts in the cement floor. The current passes from the generators through 600-ampere oil-break switches, each installed in a separate concrete compartment, to the 2,300-volt bus-bars.

The field rheostats are supported on 4-inch I-beams above the

switchboard and are operated by means of chains and sprocket wheels. The bus-bars, oil switches, and wiring for the instruments are all back of the board and out of the way, being located in an alcove on the north side of the building, as shown on pages 753 and 754. The switchboard has seven marble panels, one for each of the generators, one for each exciter, and one for two step-up transformer circuits.



JOINING TWO LENGTHS OF CABLE IN THE FIELD.

From the switchboard the 2,300-volt current is conducted to the 1,800-kilowatt static transformers, where the potential is raised to 60,000 volts for transmission. The transformers are delta connected on the low-potential side and "Y" connected on the high-potential side, the neutral being grounded. The efficiencies of the transformers as determined by factory tests are as follows:—

Full load, 98.295 per cent.; three-fourths load, 98.028 per cent.

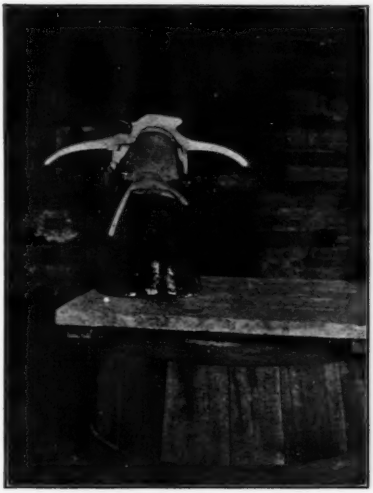
THE TOWER, SHOWING INSULATORS, CROSS ARM, AND ROLLERS FOR STRINGING CABLE.

The transformers are of the oil-insulated, water-cooled type; the tanks are 12 feet in height and occupy a floor space of 3 feet by 6 feet. From the step-up transformers the current is conducted to the transmission line, the wires passing out of the building through circular openings in the wall to a set of 60,000-volt disconnecting switches mounted just outside of the building, and thence to the first tower of the transmission line, as shown on page 754. On the inside wall of the building three rows of

60,000-volt lightning arresters are mounted, being connected through switches to the outgoing leads.

The 101-mile, 60,000-volt transmission line differs materially in design from any line heretofore constructed, notably in the use of a hard-drawn copper cable instead of the usual solid conductor, metal pins, cross arms, and towers for supporting the insulators, and unusually long spans.

The conductors are 19-strand, hard-drawn copper cables approximately ⅜ inch in diameter, equivalent in carrying capacity to a No. 1 B. & S. G. wire and weighing 1,340 pounds per mile. This type of conductor was finally determined upon, after much study and many tests, because of its high conductivity, flexibility, and mechanical strength, the wires composing it having a tensile strength of over 55,000 pounds per square inch. The cable was made and shipped in lengths of about two miles. The joints were made with special copper-tube connectors, 12 inches long and elliptical in cross section. The two ends to be joined were passed through the connector in opposite directions, and three complete twists were given by means of special wrenches. The photograph opposite shows a joint partly twisted. No soldering was done. The cables are placed in grooves on top of the insulators, 78 inches apart, at the points of an equilateral triangle, and are tied in with No. 14 soft-copper wire. In stringing, the cables were pulled over the cross-arms on rollers as shown on page 756, below. Diagrams were prepared showing the proper sag to be allowed for various temperatures and for spans up to 1,320 feet, based upon a maximum strain of 20,000 pounds per square inch. The calculations include an allowance for the mechanical elasticity of the cable.



THE INSULATOR, SHOWING ITS CONSTRUCTION.

The insulators are larger, heavier, and better than those generally used, and were required to stand a test potential of 120,000 volts for five minutes. They are over 12 inches in height and 14 inches in

diameter, and weigh about 15 pounds. They are made of porcelain with a brown glaze and consist of four parts, as shown in cross section on page 757. The top and the first petticoat were glazed together in the kiln, and the other two joints were made with neat Portland cement. The pins were likewise secured into the completed insulator. The pins are of cast iron, conical in shape and cored hollow. The pin which carries the top insulator has an enlarged base, threaded on the inside, and is screwed on to the end of the 3½-inch extra-heavy pipe, which projects from the top of the tower. The pins which carry the lower insulators have rectangular bases securely clamped between the ends of the 4-inch channels which constitute the cross arm.

The towers are special 40-foot, four-post, galvanized-steel structures, made of 3-inch by 3-inch by 3/16-inch angles, braced and stayed with smaller angles and rods. Each post terminates in an anchor consisting of a piece of angle iron 30 inches long secured at right angles. The towers are spaced 440 feet apart, twelve per mile, except near Guanajuato, where the nature of the ground necessitated the use of a few 60-foot towers and spans up to 1,320 feet in length.

Two No. 9 B. B. double-galvanized iron wires for a telephone circuit are fastened on the transmission towers ten feet below the copper power cables. They are tied to regular glass insulators placed on 12-inch painted oak brackets bolted to the tower legs. The telephone wires are transposed one complete revolution every four towers; the power cables are not transposed. High-resistance instruments are used, and the telephone service is quite satisfactory.

The line is divided into four sections of about twenty-five miles, and is in charge of a superintendent whose headquarters are at the middle storehouse. At each of the three division points there is a first-class storehouse, a set of 60,000-volt disconnecting switches in the main line, a line foreman, and patrol man, both mounted. In the middle of each section there is a second-class storehouse in the care of a mounted patrol man.

At Guanajuato the transmission line cables enter the sub-station through a set of 60,000-volt disconnecting switches the same as at the generating station.

The Guanajuato sub-station is a handsome stone building with brick trimmings and a flat roof, standing in a beautiful grove of trees. The dimensions of the building are length, 113 feet, width, 89 feet. There is a central portion two stories high with well proportioned one-story wings on either side. One wing contains an office for the

general manager, a drafting room, an accounting room and a reception room. The other wing is fitted up for a repair shop and store room. The central portion contains the transformers. A 10-ton hand-operated crane runs over the shop and transformer room, passing through folding iron doors. The electric current enters the building, passes a set of lightning arresters with disconnecting switches, like those at the generating station, and goes to a bank of oil-insulated, water-cooled transformers where the line potential is reduced to 15,000 volts. These transformers are rated at 970 kilowatts each. Their efficiencies as determined by factory test are as follows:

THE SUB-STATION AT GUANAJUATO.

Full load..... 98.193 per cent. efficiency
Three-fourths load ..... 97.93 per cent. efficiency

From the step-down transformers the cables pass through ducts under the floor to the switchboard, thence to the six 15,000-volt, three-phase distributing circuits, each of which is equipped with lightning arresters and air-break switches with tube fuses.

The solid copper wires of the distributing circuits are carried on 5¼-inch brown porcelain insulators, supported on wooden pins in wooden cross arms on square yellow-pine poles, 30 to 35 feet in height, 9 inches by 9 inches at the butt, and 7 inches by 7 inches at the top. The iron telephone wires are carried on the same poles, but are frequently transposed. The power wires are not transposed.

At the mines and mills where the electric power is used the potential is reduced in three-phase transformers from 15,000 volts to 460 volts for motor service. The Guanajuato city two-phase, 2,100-volt lighting system is supplied through a bank of 150-kilowatt, three-phase to two-phase transformers with a feeder regulator in each phase.

A branch line extends to Irapuato, the "Strawberry Station" on the Mexican Central Railway. The Irapuato sub-station is a brick building equipped with 60,000-volt disconnecting switches and lightning arresters and the following oil-insulated, air-cooled transform-

HAULING THE GENERATOR ARMATURE THROUGH THE STREETS OF ZAMORA.

ers: Four 200-kilowatt line potential to 15,000 volts, four 75-kilowatt 15,000 to 460 volts for motor service, two 40-kilowatt 15,000 to 2,200 volts for the city lighting system.

Power is supplied to various small industries throughout the city, including three grist mills, a foundry, a wagon works, a paint factory, and various pumps used in irrigating the strawberry fields.

To the ingenuity of American engineers, backed by American capital, is due this noteworthy development by which the energy of the swift and boisterous Duero River has at last been harnessed, and after conversion into electricity has been transmitted over the 100 miles of intervening country to revivify the mining and other industries of the picturesque old city of Guanajuato, famous for its great mines, which are said to have produced during the past 350 years, about one-fifth of all the silver in the world. Of late years these mines have not been worked to any great extent, largely because of the high cost of power.

The inception and development of this enterprise are due to Mr. Leonard E. Curtis, who had been for a long time counsel in patent matters for the Westinghouse Electric & Mfg. Co., and who had been obliged to leave New York and go to Colorado on account of his health. He was sent to Guanajuato by clients to examine the title to certain mining properties, and it occurred to him that the conditions there were exceedingly favorable for the introduction of electric power if a suitable water power could be found within working distance. He employed a young American, whom he found there, to search for a water power, giving him a radius of 100 miles from Guanajuato to work in. The water power which has since been developed was found, and an option obtained on it during the following year. In the meantime Mr. Henry Hine, under whose management the Stanley Electric Manufacturing Co. had been built up, and who had resigned his position in that company when the ownership of it changed hands, had joined Mr. Curtis in Colorado,

quickly subscribed the necessary capital, subject to an engineering examination, which was made by Mr. Robert McF. Doble, of San Francisco; Mr. H. H. Filley, of Kansas City, and Mr. Charles T. Main, of Boston. Their report was favorable.

The designs and specifications were prepared in San Francisco. The materials came by sea and by land to the railway station at the quaint Mexican city of Zamora, whence they were hauled on wagons. The task of hauling to the construction camp was by no means easy, although the distance was not more than ten miles. The way lay through the city of Zamora, thence to the little town of Jacona, and thence about six miles along the State highway to the construction camp at the little Indian village of El Platanal, where the power generating station is located.

American mules were purchased and specially designed American wagons were provided in order that adequate means should be at hand for carrying the heavy parts to their places. The roads through the country are mostly over black adobe soil of indefinite depth. A few rainy days are sufficient to convert such roads into regular quagmires. The haul through Zamora and Jacona was by far the worst part, since the streets had been improved (?) by a pavement of stones of no small diameter, and in spite of the wide tires the wagons would break through the pavement into the underlying mud during the short intervals of time allowed for the animals to rest. The cut opposite shows a team of twenty-one mules hauling the lower half of the armature of one of the generators. To get this load safely over the city streets required the combined efforts of two American superintendents and ten peons, all directly interested in some way in the moving of the load. Two wagons followed carrying jacks, block and tackle and tools for making repairs en route, forming in all quite a procession.

The short time in which this project was executed is most remarkable and is characteristic of the management. The preliminary examination was made in March and April, 1902, construction was begun in the fall of the same year, and in October, 1903, the plant was put into regular operation. This undoubtedly establishes a record in Mexico for rapid and efficient execution of construction work of a technical character and of considerable magnitude, especially in view of the fact that the work was completed within the estimates of cost.

ORGANIZING THE MACHINERY-SELLING DEPARTMENT.

By Russel M. Seeds.

While Mr. Seed's topic is frankly commercial rather than technical, he makes so admirable a presentation of a matter which is integrally connected with modern industrial success that we deem it well worthy a place in our works-management series.—The Editors.

UNQUESTIONABLY the average house building heavy machinery regards the whole advertising business as an expensive nuisance, necessary because competitors do it, but none the less, a source of great expense and bother. With the notion of "holding down" this expense to a minimum, the advertising was once handled by the head of the house, or delegated by him to one of the more responsible officers; and this plan is still followed in a number of concerns. It is distinctly bad. When the man handling the advertising has more important and more immediate duties to absorb his attention, he is quite apt to throw away more money than would pay the expenses of a well-organized advertising bureau that would be a proven profit-bringer, instead of an uncertain expense. In the advertising proposition of any concern seeking to spread its trade throughout the country or to increase an already widespread business, there is plenty of work to keep one high-class man and several clerks busy. Logically this work should include the making of catalogues, the procurement of photographs, wash drawings, and engravings, the contracting for space and preparation of space advertising, the collection of lists and preparation of letters and other matter for direct advertising, and the collection and following up of special information that may be developed into inquiries.

It is the business of advertising to locate the customer and develop an inquiry. More than that it cannot do toward placing the product of the builder of heavy machinery. It cannot "create a taste" for heavy machinery. There must be an existing need. The man with the need must be discovered; and when he has made his needs known and asked for quotations, advertising has gone as far as it can go. It then becomes a question for the salesman to handle.

The house feels the need of high-class salesmen, because it understands what class of men they come in competition with in their work.

The house should understand, and the advertising man himself should understand, that every catalogue, every space advertisement, and every letter he puts out is quite likely to meet in competition the work of very superior brains. There is always someone among competitors who does some part of the job, if not all of it, better than he. It is not a position to be held by a clerk, but by a man of intelligence and judgment, supplemented with a certain amount of special knowledge.

The status of the advertising man and his bureau in the business is something of a mooted question in a good many machinery-building establishments, and this is largely the fault of the advertising man himself. As a general thing, he is given a free lance and an uncertain status at the start, and he either develops into a rather expensive clerk or an essential part of the business organization, according to his ability and deserts. Unquestionably the advertising bureau should be a part of the sales department, and its chief should report to the head of that department. Lack of harmony between the two is fatal, and the best way to obtain harmony is not by making co-ordinate departments to handle propositions between which the dividing line is hard to define. Preferably the advertising man should owe his employment to the head of the sales department. The latter will be wise if he selects a good man, takes the trouble to understand him and his work thoroughly, and then gives him as much leeway as the circumstances and the character of the man will admit. The advertising man should be in close touch with the engineering department and have early knowledge of all changes of standards, and he should know enough about costs and prices to know what goods carry a profit and what do not. He should know enough of the finances of the concern to know how heavily it can afford to gamble from month to month on advertising. An "advertising appropriation" is a mistake. It is never possible to guess the right amount in advance, and thus a fixed appropriation is either a dangerous temptation, if it be too large, or an annoying limitation, if it be too small. It is all right to have it as a myth, for often the easiest way to refuse an embarrassing request is to hint at an exhausted appropriation; but, as a matter of fact, there should be no appropriation. Above all, the advertising man should know the selling proposition of the house from top to bottom and should be in daily touch with the sales. Direct selling may mean one method of advertising, and an agency system quite another, while selling through the general jobbing trade might mean still another general advertising plan. And, if he is to

know when, where, and how to advertise, he should know in a general way what sales are being made daily and where the goods go. He should, of course, review all the inquiries of the house daily, and have a quick method of determining whether or not a particular inquiry originated from advertising, in order that no inquiry be delayed more than a few minutes on its way to the trade desk. A list of the inquiries submitted to him is not sufficient. There are points about the letter and even the letterhead that may be valuable to him in his efforts to trace. He should also have the fullest co-operation of the head of the sales department in establishing a simple system of following such inquiries as he traces to advertising, until they are either sales made or sales lost. Finally, he should be required to account for every dollar expended for advertising in any form, and to show at least twice that much money brought back in the shape of profits on goods sold on inquiries indisputably traced to advertising. It may be a bit unfair to base his returns on sales, instead of on an agreed percentage of acceptable inquiries, but it has a tendency to make him a constant and intelligent critic of the selling methods, and honest criticism is a wholesome tonic in any business. This requirement that the advertising man "make good" also has a remarkably conservative influence on his judgment. It is not by any means an impossibility in heavy machinery, and the man that cannot do it ought to get out and try something else.

After the man has been chosen, the scope of his work decided upon, and his status in the business organization determined, how shall he go about his work? First, he must know the product of the house and its field very thoroughly. He should not only know all the details of the machinery built by his concern, but he should also know how they compare with similar features of competitors' goods. He should know in what kind of plants his goods are used, and he should know at what seasons such plants plan improvements and in what parts of the country these plants are located. He should know who buys the goods, and who tells the buyer what to buy, and who tells this man what to tell the buyer. What manner of men are these, what are their habits of thought and observation, what will interest them most and how best can they be reached? All these are very interesting and very important questions, and in their partial solution lies the reason why the man who has grown up with the business frequently does much better advertising for a machinery house than can possibly be done by the professional advertising expert. The men he appeals to are usually busy men and men of sense. First of all they want

a good, clear picture of the machinery and some indication of its capacity. The rest must be a truthful message, briefly told, without either startling or humorous effects, or anything that smacks of the catch-penny.

The advertising man should be equipped with a fairly thorough knowledge of photography, of the making of wash drawings, of engraving and of printing. All these people do better work when the man they are doing it for understands what they are doing and cannot be fooled. If a bad job comes from the press, he must know whether it is the fault of the photographer, the artist, the engraver, or the printer, and should know just how and where he "fell down." At the same time he should bear in mind that criticism properly made encourages, while the other kind kills; and he should further remember that in all this class of work, where there are a thousand and one chances to cut, one seldom gets more than he pays for in the way of quality. Cheap engraving and printing always show their price very plainly—and a house is better off with none at all. A house is known by the character of its catalogues and printed advertisements and these carry a very well-defined impression of the grade of goods it turns out. Dignity, elegant simplicity, clearness, and perfection of detail are the points to be desired.

Space advertising is the knottiest problem with which the advertising man must deal. It is here that the great opportunity for waste of money or for profit lies. At best the effort to trace results is unsatisfactory. Such keys as post-office-box numbers, street numbers (outside the largest centers of population) or department designations, are wasted. The buyer is usually intelligent enough to know that your mail, addressed to your city, will reach you and that an inquiry will reach the proper department in due course. He will not take the trouble to help you sort your mail. There are, however, ways of keying, such as putting a different designation under the cut used in each paper, that serve fairly well. The first question in space advertising is that of mediums. It is easy to learn what are the leading periodicals in each field—and there are never more than two or three at most. The new ones and the little fellows are wasted money and time, no matter how low their rates. A considerable part of the value of space advertising is the impression of your standing in the trade it makes upon your public, and this kind of value can be given only by mediums of established reputation and dignity. If you have anything new to introduce, exploit it fully with all the space necessary to show and explain it. Otherwise, space enough for one or two illustrations

and a full list of your product is sufficient. And there should be a change with every issue. This takes time and a system of keeping track of things, but it is not difficult.

A big question in the space advertising is whether the advertiser shall endeavor to cover all the fields in which his machinery is used through the journals representing those fields, or confine himself to the journals representing his own line of manufacture. We studied questions of selling long before we studied advertising, and finally reached the conclusion that people with large propositions, like machinery houses, wholesale houses, and the like, had better congregate in districts, for buyers would come where they could get the most competition; while retail grocers, druggists, and the like, should scatter out among the buyers' homes. If the proposition is small, with widespread consumption, scatter the advertising; if it is big, confine it to your own line of papers. The manufacturer seldom buys machinery without consulting the mechanical engineer, stationary engineer, architect, or millwright, and these read the periodicals devoted to engineering.

If the new or weak periodical is of little value because of its small standing, how is it with the "sporadic" publication, the one-time effort that has no standing at all? These propositions are the terror of all intelligent advertising men. If the head of the house wants to put some money in a church-fair or labor-day programme, if he wants to appear in "Our Local Industries" or sign a "Business Men's Proclamation," or spend money on some other fake, he has the right, of course, to do it, but it should be charged to donations, not loaded on the expense account of the advertising bureau.

A word about the much overworked "write-up." If you have something new and interesting, the papers on your list will usually be glad to use it in their reading columns, but they do not want to—and the good ones will not—describe things that have been on the market for months or years, nor is it of any interest to anybody but your competitor to learn what sales and shipments you made during the past month.

There is, however, one form of the "write up" that is made by the publication itself, to which the advertising man should give all the attention possible. It comes, like angels' visits, rarely and unexpectedly, but when its full advantage is reaped it is worth more than all the advertising space money could buy in that particular periodical, if it be one of the better class. For the purpose of some general article he has in mind, the editor sends out a request to a few leading

concerns for photographs and data describing their product or some part of it. Since the article is to go into the body of the reading pages of the periodical, it will be read and it will carry the impression that the machinery houses mentioned therein are the leading ones in the trade. There is nothing better in advertising than this, and it behooves the house not to dismiss it by mailing a catalogue covering the point. The editor is quite apt to be as lazy as you are, or he may not be sufficiently familiar with your catalogue or with your trade to dig out the data he wants. Study intelligently what he wants and give it to him in the shape he wants it. Get good photographs, if you have not them at hand, and put on the back of each the name of the machine, its capacity, and other essential details, as well as your firm name. He has probably asked others for similar information, and he cannot know by instinct the photographs sent by one house from those of another, nor does your letter of advice, sent under another cover and arriving at a different time, help in the identification. It is well worth spending time and money to do this right, for it is the best advertising that can be got in any way.

Not by any means the least of the advertising man's work is the building up of a proper system of direct advertising. Up-to-date catalogues should be in the hands of every man interested in any way, or likely to be interested, in the machinery of the house. These lists are hard to get and still harder to keep corrected, but the returns are worth the effort. It pays to keep in constant touch with a very large number of such people by means of a systematic correspondence, and it also pays to gather special information from all possible sources about new plants, replacements, etc., and to endeavor by correspondence to verify this information and develop it into inquiries.

Advertising, if intelligently and industriously done, can be made a sure source of profit, instead of an expense with intangible hopes of profit—and the only kind of genius it requires is a fund of common sense and a capacity for a great deal of hard work, coupled with a systematic method of handling a large amount of detail.

THE ENGINEER, THE ARCHITECT, AND THE GENERAL CONSTRUCTION COMPANY.

By Reginald Pelham Bolton.

The disorders and abuses cited by Mr. Bolton could not fail to be a menace to the welfare of both the professions involved, and to the best interests of the community at large. In presenting the article, the editors are actuated by the same motive which inspires the author—the hope that a straightforward and plain statement of the matter may work for the removal of the evils, and the readjustment of conditions on a sound and honorable basis.—THE EDITORS.

THE architectural profession has not infrequently recognized its responsibility for the results of its professional work, and has advanced in many ways along lines of modern development. But it has curiously failed to recognize its responsibility in another and more important respect, namely, that of the acceptance of fees in payment for certain technical and artistic work which its members are not qualified by training to execute, and in which they are not expert in the same sense as they are in connection with actual building design. The position occupied by the profession in this regard is not logical, and has brought about a very disastrous state of affairs as regards their employment in the largest building enterprises.

As the logical reason for the employment of professional ability in the design of a building, in place of the employment of contractors or builders for the purpose, it is maintained by the profession that their members are a trained body, expert in the design and proper construction of the work they undertake to plan, uninfluenced by the considerations which affect the contractor or builder, and capable of giving economical and independent advice to their clients.

The client, it therefore follows, in employing an architect, engages and pays for a personal ability and technical knowledge of the subjects under consideration and is entitled to a receipt of that personal capability and technical information in each branch dealt with.

If, therefore, the architect does not possess expert knowledge on any one branch of his undertaking—and no one can expect that any one of that wide profession should be so fully informed—he is under moral obligation to supplement his own deficiency in respect of any particular item involved—such as, say, sculpture, modeling, decorative

effects, landscape gardening, sanitation, boiler practice, chimney design, electrical equipment, heating, ventilating, hydrostatic, elevator, foundation, steel construction, or other modern requirements—by the equivalent expert and equally independent knowledge of others; otherwise he is not giving his client value for his engagements.

In other words, architects are paid for professional knowledge and experience upon all parts of the work they undertake, and cannot honestly accept pay for their services as amateur sculptors, artists, engineers, plumbers, and for amateur opinions upon technical subjects. Yet too many of them not only do so, but still adhere to the old practice of obtaining information, guidance, proportions, even their plans and specifications, from contractors and prospective bidders.

As regards engineering work, there are a few architects who by reason of a certain amount of habitude, possibly in some cases of a certain amount of training, possess a familiarity with some sanitary and engineering matters. But would they, if deprived of their architectural practice, undertake with that amount of knowledge to enter upon independent practice as experts in those lines?

In other words, will any architect assert himself to be as fully qualified in these matters as he professes to be, and is, in building design and construction?

Recognizing the necessity of doing something, but desirous of avoiding the cost of employment of ability of a character and cost equal to their own, a number of architects have proceeded to a course which has proved peculiarly adverse to the interests and credit of the profession. They hire inadequate and often inexperienced help in the shape of assistants or draughtsmen, and put them forward as their substitute for technically trained expert assistance. One of the foremost firms of architects in the United States have in their employment, and put forward as their "consulting engineer," a very worthy, and in his own line deserving, man whom they took out of an engine room. There are several others who pay their "consulting engineers" in their office from $20 to $30 per week, and permit this class of experience to pass upon and decide the important operating expenses of their clients. Such men are not only incompetent in the direction of knowledge, experience, or ability, but an injury is inflicted upon the client which often reflects back upon the architects, by placing such a class of men in control of matters where large sums of money and many competing and unscrupulous interests are engaged.

The very essence of the employment of professional men is that their "standing" shall protect the employer from corruption and

undue influence; and in passing over any part of their engagement to a lower class of employed and often underpaid labor, the architects very seriously compromise their employer's interests. Even when an independent engineer is employed he is often made to feel that he is only the agent of the architect or is placed under obligations to make his designs coincide with the architect's views. The results are to be seen in many otherwise well-considered installations.

There are eight hundred and fifty practicing architects in New York, and there are seventeen independent consulting engineers employed on such cognatic work, where there should be plenty of inducements and work for ten times the number. The architectural profession have had this matter drawn to their attention by several engineering societies, and have not only failed to correct their false position, but have embodied it in the provisions of their form of professional contract. As their self-sufficiency evidently renders them deaf to the calls of plain dealing, it is necessary to direct the attention of those who employ them to the matter, so that the existing system may perhaps be remedied from without. I shall not lay myself open to any charge of one-sidedness, but freely admit that there are some engineers posing as architects to whom the same consideration can be inversely addressed. But it is to the general credit of my profession that they are an extremely limited number.

It is in connection especially with steam apparatus that this matter assumes peculiar proportions, for in this the owner's pocket is particularly and permanently assailed. If a few personally conducted parties of steam users could be taken through some of the most modern firerooms in New York they would certainly be convinced of the desirability of employing engineers on engineering work. A trip up Broadway would reveal boilers in dark and stifling sidewalk vaults which are a menace to public security, since boilers so placed cannot be properly maintained in security; boilers far away from the chimney, necessitating horizontal smoke connections, in one case 225 feet long; boilers, as in one well-known and widely illustrated building, so badly placed and connected that when steam is raised in one the expansion pulls the piping off the other, or, as in one of the largest insurance buildings, placed in the same room as the machinery, with space for only one day's fuel. Such instances could be multiplied.

Owners are of course largely to blame. But they do not realize what the position is. The mechanical plant in a large office building is worth from $60,000 to $150,000. On this an architect commonly receives his commission of 2½ or 5 per cent., or from $1,500

to as much as $7,500. His outlay in respect of its design is frequently nothing, the whole being obtained from contractors.

The steel structure may be competed for by more than one firm of contractors, but each maintains its own drawing office, sometimes employing as many as 100 to 150 draughtsmen, the cost of which labor is added to the price; and thus the planning of this part of the work is frequently paid for by the owner of the building twice over.

The Building-Construction Company.—The unsatisfactory conditions of service, as offered by the majority of the architectural profession, have led to the introduction of a recent development of the pretentions of the builder to the possession of the facilities of the architect, and for this development, directly hostile as it is to their own pretentions, the architectural profession have themselves, in their persistence in the foregoing practices, entirely to blame. I state this fact from personal knowledge of the reasons which induced the introduction in New York of the present system of general construction, the foregoing conduct of the architectural profession having been given to me as the cause by two of the leading concerns against whom the architects of New York are now loudest in their denunciations.

By dint of liberal assertion, of active exertion on the part of young and alert employees, and of constant iteration of architectural shortcomings, the construction companies have plucked the ripest plums from the building orchard. They have calmly adopted the plans of architects, without credit or thanks, have walked off with their clients, belittled their abilities, thrown doubt on their capacity, sneered at their rectitude, and cold-shouldered their approaches to any understanding.

Their particular facility is that they, for a covering figure, can carry out all architectural detail and engineering work without cost and with their own trained staff. This would be an excellent idea, if the staff were of that character; but in point of fact, they have not yet grasped the fact that it would pay them to employ the highest class of professional ability; and therefore the men employed by them in the work of design are often either small contractors, or are assistants of the same order as those to whom I have referred as being employed by some of the architectural profession. If the scope of these powerful concerns should eventually fully cover the field of building operations, the profession of architecture would be very completely visited for its shortcomings, since the avowed idea of the construction company is to allow the architects no more than the

opportunity of producing general designs to be by them detailed and developed; but so far, owing to the very similar class of intelligence applied to their work of detail design, the result has often been poor architecture and more often still poorer engineering.

In respect of the latter, I regret to say that since the operations of these construction companies began, no advance whatever has been made in the improvement of the interior engineering of the buildings they have handled. In point of fact, their practice at present is the installation of poorer designs of mechanical equipment than were generally discredited before their methods obtained an ascendency in modern building operations.

It is but a natural result of such a system that this should be the case. A general contract for a great building is made on a condition which is the essential feature and object of the employment of a general contractor. It is that a building of a certain character, often identified only by a mere sketch or outline, or even by a partial reference to some existing building of a more or less similar type, shall be erected within a certain period for a certain sum, without any extra charges. Any attempt to introduce any detail of conveniences, of desirable materials, or of particular requirements, is met and combatted by the objection that the builder must have a free hand in selection or in dealing with competing manufacturers; otherwise the cost will be increased, or the time limit will be exceeded, or labor trouble may ensue. So the owner signs away his money and gets in return a complete structure, it is true, such as his picture showed, which is however built of the material, equipped with the class of apparatus, proportioned to the extent of liberality, and constructed by the class of labor, which have best suited the policy or profit of the contractor. If by the inducement of the needs of this building a gain can be made in another; if by the sacrifice of a detail in one an extra can be avoided in another; if by diverting proper labor from one, less competent or cheaper labor can be utilized in another—then these policies are open to adoption, are liable to be adopted, and are and have been in many cases adopted.

As to the designing work produced under this system, it is inferior and is done by inferior help, whose efforts are subordinated to the one predominating consideration of avoiding all avoidable cost, while at the same time evading the much abused "extra," which in this class of contract, coming directly on the construction company, is of course to be avoided at all cost of sacrifice of efficiency. I will give an instance of an actual occurrence:—

In the construction of one such building it was discovered that by a blunder in reading, or more likely by an error in estimating, no provision had been made for the cost of carrying the decorative "effects" of the two outer sides of the building round its interior sides, which were exposed by the ownership of the abutting property. The difficulty was overcome by directing the engineer to cut down the equipment to a sufficient extent to pay for the deficiency.

The proper equipment was, therefore, cut from two boilers of ample capacity and one spare, to two boilers which, when forced, can just do the work; two generators which unitedly will barely carry 5/10 of the total lighting load, and 6/10 only by overload; the omission of every possible convenience and cross-connection; the reduction of the plumbing and character of the fixtures; and the skinning of the heating arrangements down to the cheapest system. The owners have the satisfaction of knowing that their building is carried out "without extra," and has cornices of the anticipated appearance. But they do not know that they have not only paid an extra in full for the work, but also are paying an extravagant and permanent interest on the achievement, in their coal, repair, and labor bills.

The Owner of Property.—I could multiply these instances, but I do not know if there is any good in attempting to draw beneficial lessons for the education of an educated class which is, withal, too careless or incapable to take elementary precautions as to its own rights and property. One would suppose that a most limited intelligence would enable a property owner to perceive that he is not likely to get something for nothing out of a smart firm of general contractors.

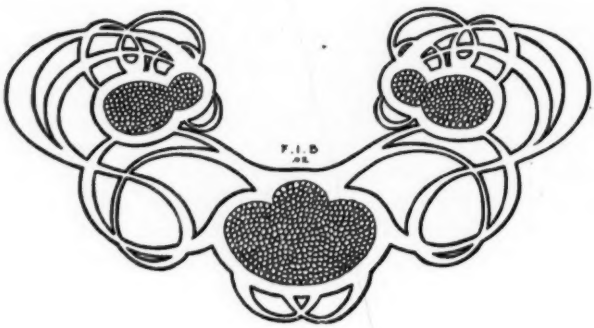
As regards the features of engineering character in their buildings, it might naturally be assumed that men of business capacity and of ordinary intelligence would, in a matter in which they are directly and permanently liable for the cost of results, very closely examine into the conditions surrounding their future outgoings, with the aid of the best technical knowledge available. But that is rarely the case. Such people, when contemplating the construction of a building, are captivated by the ideas of outside design and interior decoration, and are under those influences to such an extent that the hard and mechanical details of engineering operations are uninteresting to them. They are also very frequently dependent in all such matters on some mechanic in their employment, such as the operating engineer or fireman in their own home or other property. These men, when put forward (as they very frequently are) to discuss or suggest or even

to proportion necessary apparatus in a new building, do so with the natural subserviency of their class, and come under the architect's or contractor's dominance, their employment in this manner often resulting in worse blunders than would have been the case without their limited ideas, and their liability to accept all kinds of assertions on the part of manufacturers.

Not until it is much more widely understood that the mechanical apparatus in a building is the part of it that directly affects the pocket of the owner, that in it and by it he is constantly being defrauded and fleeced, will the present state of affairs be amended.

I have recently had the opportunity of laying these views before one of the great mortgage-insurance companies, whose action will in future take into account the imperfections and deficiencies of mechanical apparatus in the building in which they take an interest. It may be that others will awake to this, to them, important element, and that through their action careless ownership will be aroused.

Having sat for ten years past between these elements, and having had the good fortune not to fall into the evil graces of either, I am in hopes that my plain speaking will be taken in good part and that all parties will proceed to set their courses with a little more regard for their true interests in this age of engineering detail. And I am thankful to record my knowledge that there are architects who fully live up to their undertakings in the respects I have named, as there are builders who are conscientious, and as there are owners who are capable of appreciating the value of the old saw—"Every man to his trade."



THE TOOL ROOM AND ITS FUNCTIONS.

By John Ashford.

II. THE TOOLING OF MACHINES.

Mr. Ashford's first paper appeared in our special issue for last month—that is, in the Second Labor-Saving Number, dealing with labor saving in works management. In that, Mr. Ashford discussed the general equipment and arrangement of the tool room. In this he takes up its mechanical functions.—THE EDITORS.

IN the article upon the Tool Room and its Functions which appeared in the preceding issue of the Magazine, there were summarised the particular functions that the tool room must fulfill if the work in a modern engineering establishment is not to be excessive in cost. The first of these functions indicated that the cost will be excessive "if the producing machines of the factory are not properly tooled." Thus by inference, the leading function of the tool room should be to provide the necessary small tools, that the producing machines may be operated to their best advantage.

I have already urged that there should be a good tool designer associated with the tool department, his duty, in addition to preparing drawings of tools and appliances, being to keep a register of those made and to arrange where they should be kept, and to decide the identification and location marks to be put upon them. This draughtsman should have a clear conception of a comprehensive tool scheme, and he should have a hand in determining the machining processes and the machines to be installed in the factory. By the exercise of a little foresight in the tool scheme many after difficulties and expenses may be avoided.

Developing this idea somewhat, the first important point that I would like to press home is the matter of *interchangeability* in tools. This to too often neglected, although of importance equal to the standardisation and interchange of parts for the machinery to be manufactured, and consequently much money is literally thrown away by the unnecessary duplication of tools and in delays while they are being sharpened, adjusted, or repaired.

That the output of the producing plant may be brought up to its maximum, the machines should be in actual operation doing useful work of production for as nearly as possible 100 per cent. of the work-

ing time. When a lathe is being used to turn up its own centres the work done may be useful, but it is not producing an article for sale; therefore, in the meaning of this discussion it is not doing *useful work of production.*

Speaking of lathe centres, it is too often found that the centres of one lathe cannot be tranferred to another; consequently, they have to be turned in the lathe to which they belong and this becomes tool jobbing. Anything that is produced by *jobbing*—that is to say, an odd item at a time—is always more costly than the production of a number of parts at once, by properly prepared methods and appliances. Thus, for a shop having several hundred lathes, it would be less costly to keep the centres in good working condition if they all had similar shanks, so that they could be made and repaired, a quantity at a time, in the tool room. A constant taper throughout for these and several standard sizes would make it possible to keep them in proper repair at much less cost, and at the same time prevent the otherwise certain interruption of work in the producing lathes.

The question of tapers for tools needs tackling in every engineering shop, for there are so many different angles found in actual use; it would be a great convenience to users if the various tool makers could mutually agree upon some definite standard. We already have the Morse taper for drills, the Brown and Sharpe tapers used by several firms for arbors, etc., and in addition a multiplicity of tapers by various firms for lathe-centre shanks, boring-machine spindles, etc. Suppose that tapers in drill spindles, milling-machine mandrils, lathe spindles, boring-machine bars, and other cases where needed, were all alike—what a convenience it would be! The tools for any one of these machines could be used on any other without the need of special holders, and the actual numbers and variety of tools required in a shop would be materially reduced; it would be a big step towards interchangeability in tools.

The successful running of a tool department will depend upon the value of the tools it produces. Thus it is advisable, nay necessary, that its product should be of the very best quality that can be made, both as regards material and workmanship. The value of this product will be very greatly enhanced if the department takes all necessary steps to secure real interchangeability, so that it can reduplicate any part or prepare spare details with the certainty that they will fit. To this end the method of producing the tool must be carefully thought out and jigs or gauges prepared for it; these tool-room tools, as we may call them—tools for producing tools—being registered and stored

with even greater care than those for use in the shop, and on no account should they be allowed out of the tool department.

To illustrate this point, take a very common instance, namely, chucks for drilling machines. In addition to the pure work of drilling holes, much work to be done upon a drilling machine requires a pulling force towards the drill spindle; for example, the facing of circles round bolt holes on the under side of flanges to receive nuts. For this work an ordinary taper chuck or collet as used for a drill is not enough, as the tool would draw out; consequently, to avoid adding other kinds it is convenient to provide the taper chucks with a holding device such as a pinching screw, a draw cotter, or a plain drilled hole for the insertion of a piece of wire of sufficient strength, of which devices I would choose either of the two latter, preferably the draw cotter. The holes, whether for the wire or cotter, must, in all the chucks and shanks of tools, interchange with one another. This can only be done by using jigs for their production and these must *take their setting,* in both cases *from the tapered portion* of the shanks and sockets to be drilled.

It has already been suggested that it is expedient to use the best material obtainable for the making of tools, for it is a penny-wise pound-foolish policy to put inferior material into any kind of tool. The rate of output from a machine is largely governed by the speed of cutting that the tool will stand; and also, the accuracy of the work will greatly depend upon the ability of a finishing tool to retain its cutting edge and its size. In addition to this, good steel requires less frequent sharpening and so costs less in the tool room for maintenance; thus the use of good material is true economy. Having selected the right quality it is not wise to depart from the brands used, for the different makes of steel require different treatment to get the same results; when the tool-room men are familiar with and understand the working of particular brands to secure the tempers they want, it is but to court trouble to make a change. To have too many sorts about is to open the door for the inadvertent selection of the least suitable for a given purpose. A considerable quantity of mild steel will be used for cutter bars, shanks, holders, etc., and for this a pure mild quality that readily case-hardens will be the most useful. Bright stock, although of handy form, is generally an abomination, for it often has an excess of phosphorus, and when case-hardened it fails to give a good hard skin but becomes very granular and quite short. I have many tool holders, etc., case-hardened that others would leave soft, as they last in good condition so much longer.

For roughing purposes there are many high-speed tool steels on the market, the Sheffield steel makers having concentrated much attention on their development. I have tried many of these, finding them on the average to be most excellent for working mild steel, but they do not show to such great advantage on average British cast iron. The stiffer varieties stand much better on the latter material, and of these I have been very well satisfied with "Novo" by Messrs. Jonas & Colver and "A. W." by Messrs. Sir William Armstrong, Whitworth and Co. Other makes, such as Samuel Buckley's high-speed steel and Messrs. S. Osborne and Co.'s high-speed "Mushet," are very well liked, but I have had less experience with them. With milling cutters and drills made from Novo and hardened at a good red heat in oil, very good high-speed work can be done. It has generally been considered that it would ruin ordinary "Mushet" steel to cool it off, but by treating it with oil cooling at a good red heat it can be greatly improved in its cutting powers. When troubled with a hard spot in a casting that is too expensive to scrap if it can by any means be tooled, I have successfully tooled the job, using common "Mushet" and chilling off the cutting point from a bright red by inserting it in an impression previously made in a large block of lead. For finishing steel it is hard to beat the good old brand of "Huntsmans," a supply of which, together with Messrs. Armstrong, Whitworth and Co.'s Nos. 2 and 4 tempers, I like to have on hand.

No matter how well a tool may be made it will lose much of its value if it take much time or skill to set it for use upon a machine; we should therefore make a strong point of the fact that a tool, however ordinary, should whenever possible be made *self-setting*. Tools, appliances, and jigs, to be ideally perfect, must be constructed so that the veriest fool cannot use them wrongly; for, so long as there are two ways of using, the wrong is sure to be chosen sooner or later and loss will be caused thereby. Parallel with this idea of making tools to be self-setting, we must place the rule that where it is impossible so to make them, a ready means should be supplemented to assist the mechanic in setting and testing the tool when putting it into the machine. It is almost unnecessary to insert a reminder here (though not out of place) to the effect that due regard should be given to the cost of preparing appliances and the saving to be effected by their use, so as to avoid spending money upon tools that can never bring an adequate return. In writing about tools here the assumption is that this will have due consideration, and the tools are deemed to be necessary and profitable at their probable cost.

To give a simple illustration of this self-setting idea, let us look at an ordinary bar and cutter so frequently used on drilling and boring machines. This tool in its ordinary form is a plain bar turned at one end to fit a chuck and with one or more slot-shaped holes through it in which flat steel cutters are inserted and wedged in position. This is well illustrated in Fig. 1, page 781.

It will there be seen that the cutter takes its setting at the back, for which purpose there is a recess in the cutter dimensioned A, that fits upon the bar. Obviously, the part A must be perfectly accurate in both bar and cutter and right central with the bar, for a slight error is doubled in magnitude in the hole produced. The slot must not only be correct in all respects but, particularly at the back where the cutter fits, it must be square with the axis. If due care is given to these small points the cost of maintenance becomes trifling as the cutters can be made in quantities. A good way to deal with these is to prepare blanks, and machine a number together to all dimensions except the over-all length. A mandril similar to a bar with a slot in it is made for use upon the universal milling machine with the dividing heads. To finish the cutter it is put into this mandril and milled to length, the dividing head being used to set the cutter over an amount equal to the angle of relief, and to give the half revolution to bring the other end to be milled. If the knee bracket of the milling machine has a micrometer index to the rise-and-fall adjustment, this method is much quicker than turning to size and afterwards backing it off, for the milling machine does both at once.

The illustration of this bar and cutter is introduced with the further object of showing the kind of standard-tool drawings used by me. The sheets used for the drawings are slightly larger than foolscap and when a number have accumulated they can be bound in book form, for which purpose a blank margin is left. For shop use they can be mounted on stout cardboard. These sheets can also be inserted into the tool register kept by the tool draughtsman, and they can be supplied in books to all foremen and tool-stores keepers for ready reference in case they require to know whether some particular size tool is to be found in stock; when, as its location number is on the drawing, there is no loss of time in getting the tool.

It is a very common mistake to endeavour to run a tool department without sufficient assistance, and the most likely individual to be left out is the draughtsman; yet a man who is not only smart in scheming out tools but who is methodical and consistent in his designing, etc., is particularly valuable. Such a man would naturally

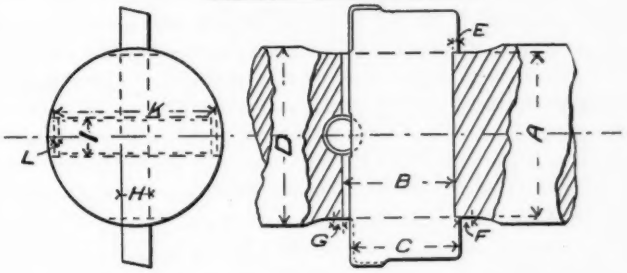
observe the types of tools that would be most frequently required in the shops, and he would arrange standard series of such tools upon small drawings like the one shown. For instance, where a number of turret lathes are used for the handling of castings, the thing would be to standardise different types of tool holders, solid and split bushes, drawback arbors with adapting rings and pads, drawback collet chucks, flat drills and holders, oil-supply drills, steadies, single-point boring tools, reamers, and floating holders, etc. For milling machines, a series of arbors, packing pieces, and side, face, and radius cutters, etc., would be standardised.

When arranging a standard series of a particular type of tool, it does not follow that all on the list are to be made at once, but as they are likely to be required. If it is not done, odd tools are made that may be used but once or twice and then put aside or forgotten and the money spent on them is stagnant, if not entirely lost.

That a given piece of work may be machined in the best and cheapest way, thought must be given to it and a series of operations fixed upon that seem the best, having due regard to the machines and tools available. This matter is often left to the foreman of a shop who, with his multifarious duties, cannot be expected to give adequate attention to it; neither can he mentally retain the particulars of processes and tools for a multitude of jobs, nor—for want of time even if he had the memory—can he impart them in detail to the men. It is therefore advisable for the operations to be placed beforehand by the tool draughtsman in conjunction with the works manager, and when fixed upon these operations, together with references to the tools, should be recorded in some permanent manner. The need for this is more particularly apparent when using high-class rapid-production machines with special tool equipment. The operations when fixed upon can be noted, when possible, upon the drawing of the work to be made, but where too lengthy it can be typewritten and mounted upon cards about foolscap size, each of which would have a reference number for indication on the drawing and for filing away. This can be best illustrated by taking some particular case and reproducing the operation lists, drawings of tools, etc. The job selected is a breech block for a 6-inch quick-firing gun, and, considering its shape, the material from which it is made (oil-hardened gun steel) and the accuracy of finish necessary, it forms almost an unique piece of work to tackle on a turret lathe. The job is machined upon a combination turret lathe made by Messrs. Alfred Herbert, Ltd., Coventry, England, and the tools were prepared by the same firm.

STANDARD TOOL LIST No 23

BARS AND CUTTERS



LOCATION MARK	D	A	B	C	E	F	G	H	I	K	L	REMARKS
	1/2	7/16	17/32	1/2	1/16	1/8	1/16	5/32	3/16	7/16	1/32	
	5/8	9/16	17/32	1/2	1/16	1/8	1/16	5/32	3/16	9/16	1/32	
	3/4	11/16	21/32	5/8	1/16	1/8	1/16	3/16	1/4	11/16	1/32	
	7/8	13/16	21/32	5/8	1/16	1/8	1/16	3/16	1/4	13/16	1/32	
	1"	15/16	25/32	3/4	1/16	1/8	1/16	3/16	1/4	15/16	1/32	
	1 1/8	1 1/16	25/32	3/4	1/16	1/8	1/16	3/16	5/16	1"	1/32	
	1 1/4	1 3/16	1 1/32	1"	1/16	1/8	1/16	1/4	5/16	1 1/8	1/32	
	1 3/8	1 5/16	1 1/32	1"	1/16	1/8	1/16	1/4	5/16	1 1/4	1/16	
	1 1/2	1 7/16	1 1/32	1"	1/16	1/8	1/16	1/4	5/16	1 3/8	1/16	
	1 3/4	1 5/8	1 9/32	1 1/4	1/16	3/16	1/8	5/16	3/8	1 5/8	1/16	
	2"	1 7/8	1 9/32	1 1/4	1/16	3/16	1/8	5/16	7/16	1 5/8	1/16	
	2 1/4	2 1/8	1 17/32	1 1/2	1/8	1/4	1/8	3/8	1/2	2	1/16	
	2 1/2	2 3/8	1 17/32	1 1/2	1/8	1/4	1/8	3/8	1/2	2 1/4	1/16	
	2 3/4	2 5/8	1 17/32	1 1/2	1/8	1/4	1/8	3/8	1/2	2 1/2	1/16	
	3	2 7/8	1 25/32	1 3/4	1/8	1/4	1/8	7/16	9/16	2 3/4	1/16	

FIG. I. STANDARD TOOL DRAWING OF SELF-SETTING BAR AND CUTTER.

The machine will be very well understood from the illustrations given on page 794, but it may be as well to explain that there are two turrets upon separate carriages; the larger one is hexagonal with a list to the back of the machine, so that long tools such as boring bars will clear the capstan handles, etc. The faces of the hexagon when presented to the headstock are central with the spindle. The smaller is square, made from a solid forging, and is mounted upon a carriage with a cross slide. Both turrets have automatic traverse; the square one has a cross traverse in addition, and it is also supplied with a chasing mechanism that works independently of the traverse, an interlocking device preventing the engagement of both at once. The mechanism that withdraws the nut from the leader screw simultaneously withdraws the chaser from the thread, a great convenience in such work as that to be described. A taper turning attachment is fitted to the rear of the machine so that the square turret may be used for taper work.

The blocks of steel, after forging, are rough-turned and oil-hardened, when they come to the machine to be completed so far as turning is concerned. The weight of the block of steel is roughly about 2½ hundredweight, and as it is of taper form it can be most conveniently held in a bell chuck while the interior is bored out, the subsequent operations being done while the block is held from the hole. Speaking generally, where the article to be machined will lend itself to the method, it is best to machine the interior first and then hold it upon an expanding drawback arbor while the exterior is tooled, as the chucking arrangements are more simple, for an adapting ring can be slipped on an arbor more readily than can pads be fitted in a collet or soft jaws be inserted and trued in a self-centering chuck. Errors are also less likely to creep in when the chucks wear.

Before commenting on the tools we will give a bare recital of the operations, the list being suitable for the guidance of the men in the shop. The operations are divided into series, being the work done at the one setting, a number of blocks undergoing the set of operations before the machine is prepared for the next series.

LIST OF OPERATIONS FOR PRODUCING BREECH SCREW OF 6-INCH QUICK-FIRING GUN ON THE No. 6A HEXAGON TURRET LATHE.

FIRST SERIES OF OPERATIONS.

Hold in large bell chuck, top of chuck to be lifted off, and forging put in with special sling.

1:—Rough-face and rough-turn outside of flange with rough-turning tool No. 1 held in square turret.

2:—Centre from turret with centring tool No. 2 held in special holder No. 3 by bush No. 4.

3:—Rough-drill small hole from turret with straight-flute oil-supply drill No. 6 held in special holder No. 3 by bush No. 8.

4:—Start large hole with tool No. 12 held in square turret.

5:—Rough-drill large hole from turret with oil-supply flat drill No. 10, using oil plug No. 14 held in 3-inch standard holder.

6:—Rough-bore large holes with oil-supply single-point boring tool No. 11, and oil plug No. 14 held in 3-inch standard holder.

7:—Finish-ream large holes with oil-supply floating reamer No. 13 and oil plug No. 14 held in special holder No. 15.

8:—Bore small hole with single-point boring tool No. 16 and adjusting collar No. 17 in special holder No. 18.

9:—Fresh centre and bottom small hole with oil-supply bottoming tool No. 19, oil plug No. 20, and adjusting collar No. 17 held in special holder No. 18.

10:—Rough-drill taper hole with oil-supply drill No. 21, oil plug No. 20, and adjusting collar No. 17 held in special holder No. 18.

11:—Rough-ream taper hole with oil-supply D bit, reamer No. 22, oil plug No. 20, and adjusting collar No. 17 held in special holder No. 18.

12:—Finish-ream taper hole and small parallel hole with oil-supply floating reamer No. 23 in rack-feed holder No. 7 held in special holder No. 3.

13:—Form radius on small parallel hole with radius form tool No. 25 and adjusting collar No. 17 held in special holder No. 18.

14:—Recess with oil-supply recessing tool No. 26 and oil plug No. 14 held in 3-inch standard holder.

15:—Finish-turn and face flange with finish-turning tool No. 27 held in square turret.

16:—Form radius on outside of flange and on edge of large hole with radius tool No. 28 held in square turret.

SECOND SERIES OF OPERATIONS.

Hold on drawback arbor No. 45.

17:—Rough-face with rough-turning tool No. 1 held in square turret.

18:—Centre from turret with centring tool No. 2 held in special holder No. 3 by bush No. 4.

19:—Rough counter-bore with flat drill No. 31 held in 3-inch standard holder by holder No. 32.

20:—Finish counter-bore with finished counter-bore No. 33 held in 3-inch standard holder by bush No. 34.

21:—Rough-turn taper with rough-turning tool No. 29 held in square turret.

22:—Rough-turn parallel part with rough-turning tool No. 29 held in square turret.

23:—Form grooves and face flange with form tool No. 36 held in square turret.

THIRD SERIES OF OPERATIONS.

Hold on drawback arbor as before.

24:—Finish face with finish-turning tool No. 30 held in square turret.

25:—Support on steady No. 37 held in 3-inch standard holder and return taper part with finish-turning tool No. 30 held in square turret.

26:—Return parallel part with finish-turning tool No. 30 held in square turret.

27:—Finish-form grooves and end with form tools Nos. 38, 39, and 40 held in square turret.

28:—Change square turret for another carrying chasing tools and rough-chase taper thread with single-point chaser No. 41.

29:—Finish-chase taper thread with double-point chasing tools No. 42 held in square turret.

30:—Rough-chase parallel thread with single-point chaser No. 41 held in square turret.

31:—Finish-chase parallel thread with double-point chaser No. 43 held in square turret.

FINAL OPERATION.

32:—Hold on drawback arbor as before and relieve taper thread with chasing tool No. 44 held in square turret using special leader.

Turning now to the tools themselves, the bell chuck is bolted upon the flange of the lathe spindle, the flange entering slightly into the back of the chuck for a centering. To facilitate the chucking of the job the chuck is made in two parts with dowel pegs at the joints to bring them truly together. The bolts for the joint are permanently hinged to the fixed part of the chuck. Eight pointed set pins of hardened tool steel are used to grip the job, and for freedom of working these and to facilitate repairs, phosphor-bronze nuts are let into the chuck from the interior. That there may be no difficulty in setting the blocks, the screws are made to project equal lengths from the exterior of the chuck when the job is central.

The first operation does not require comment, but the second draws attention to the special holder marked No. 3 (Fig. 2) attached to the hexagonal turret. The length of such holders as this is occasioned by the necessity to reach over the saddle carrying the square turret. In a lathe of this type the weight of the hexagonal turret with tools attached and its carriage is considerable, and although it can be traversed by hand with comparative ease, yet the mass to be moved prevents anything like sensitive handling necessary for feeding small drills and reamers, consequently this No. 3 holder is provided with a handle feed for drills. A pinion is seen in the drawing of the

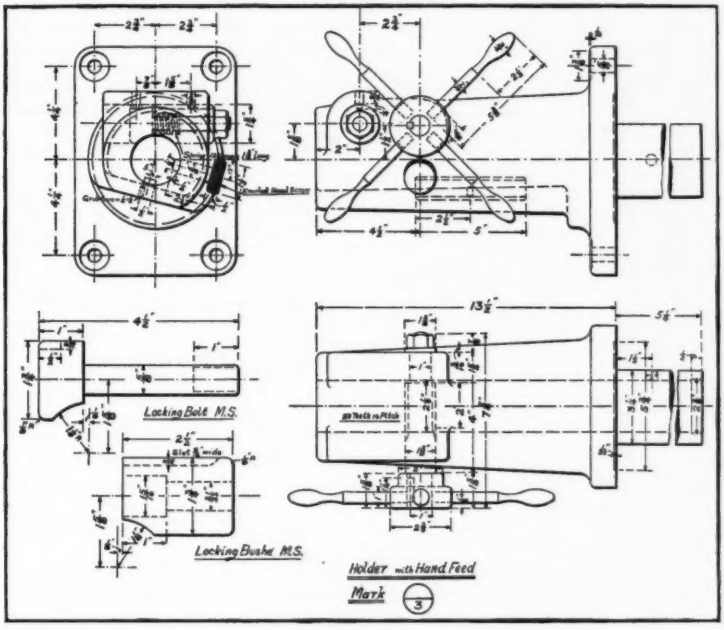


FIG. 2. SPECIAL HOLDER.

holder, and a rack-feed tool holder is illustrated in No. 7 Fig. 6. In addition to the rack feed there is a locking bolt in the holder to grip such tools as do not require the hand-feed motion, and there is also a knurled-headed pinching screw that is useful when setting tools. The centering tool for starting drills is of simple form with parallel shank to fit the adapting bush. This bush has a collar upon its fore end with a set screw to hold the drill in position when the bush is removed from the holder, and the shank of the bush is split so that the locking bolt clenches both the bush and drill when it is tightened up. Bushes of this type with various sized holes in them to take different tools are very useful, and could be arranged as a standard series fitting the various holders of all the turret lathes in the shop. In the set of tools under consideration no less than nine are actually used. The next operation is simply rough-drilling the hole with a straight fluted oil-supply drill carried in the same holder as the last. In this tool the method of making the oil-supply hole is worth noting, as it is simple to make and in the case of a stoppage from any cause is

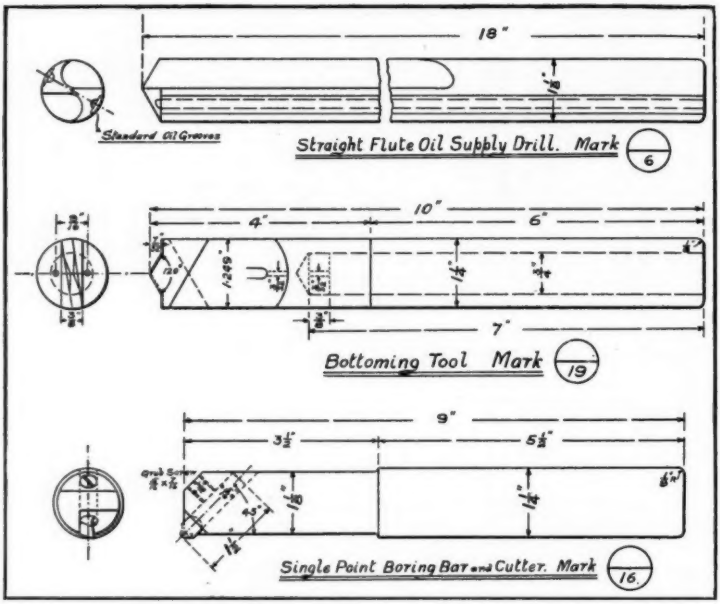


FIG. 3. STRAIGHT FLUTE OIL-SUPPLY DRILL (MARK 6).

easy to get at for clearing. The tool is shown in the uppermost drawing on the plate above—No. 6, Fig. 3.

After starting the large hole with a tool in the square turret a large flat oil-supply drill held in a 3-inch standard holder is used to rough out the large hole. The drill scarcely needs comment other than to draw attention to the oil arrangements and to the cutting lips which are quite radial. To bring the oil to the drill a plug is required to close the hole in the turret where the holder fits and direct the oil to the tool, otherwise as the turret is hollow it would be simply flooded with oil and there would be no pressure to convey the oil up to the tool. The roughing flat drill is shown on the opposite page, No. 10, Fig. 4.

When first a hole is produced by a drill from the solid or cored casting, there is no certainty that it will be perfectly concentric; in fact, it is likely to run off somewhat. To make it true a single point tool as No. 11, Fig. 5 is very good. This remark holds for both large and small holes except where the tool is strongly supported both back and front, that is to say, not overhanging as is the case here.

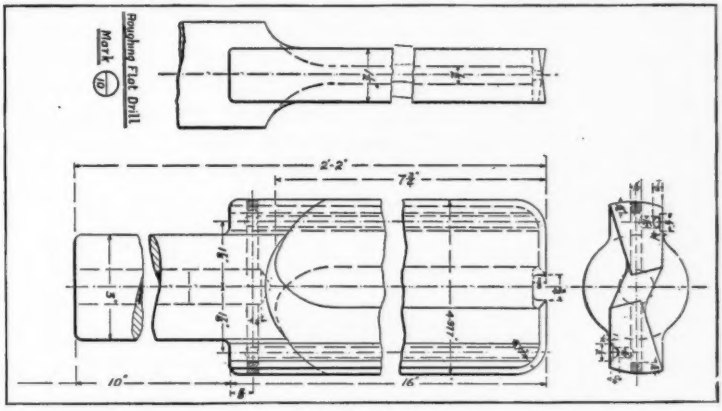


FIG. 4. ROUGHING FLAT DRILL.

Turning now to the tool No. 11 Fig. 5 to explain its points, the blades are separately made and are held in by set screws and there are adjusting screws to regulate the size of the hole. To prevent the cutting edge from pushing off when encountering a harder spot, hardened-steel steady pads are inserted at the back and bottom of the holder. To ensure the correct setting of the back cutter, it is fitted into a loose block which in turn is inserted into the holder, so that the tool can be taken out for grinding and readily be reset in position.

Let us turn now to the seventh operation, which consists of finishing the large hole with an adjustable oil-supply formed reamer carried in a special holder. That a reamer may make a hole its own size, on no account should it be rigidly held, for an exceedingly minute error of location in the turret may point the reamer out of centre an appreciable amount; consequently, the function of the reamer should be merely to size an existing hole, and to do that it must be presented to the hole and then be allowed to follow it. For this purpose the reamer is held in a floating holder—that is to say, one that will admit of a movement of the reamer in either lateral direction. The holder is bored out 1/32-inch larger than the shank of the reamer, and there is a similar difference between the retaining pin of the holder and the hole in the reamer shank. This amount of play or freedom would allow the reamer end to drop out of centre; so to present it truly to the hole, two adjustable spring plugs are inserted in the holder to take the weight, without disturbing the floating essential.

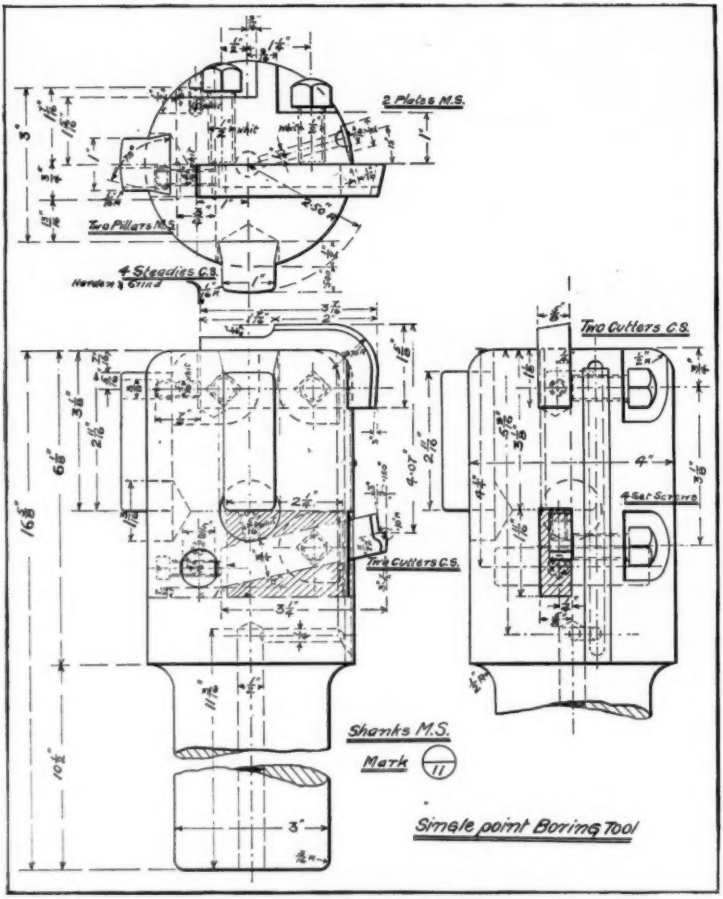


FIG. 5. SINGLE-POINT BORING TOOL.

Oil must be supplied to the reamer, for which purpose the shank is drilled, and to prevent the free escape of the oil past the shank where it fits loosely into the holder, a U leather of the same type as used in hydraulic machinery is provided as a packing. This will serve the purpose without detracting from the "floating" of the reamer.

The small hole now has to be finished, and as it is quite possible that it drew out of centre somewhat when first drilling, it must be trued up with a single-point boring tool, eighth operation. This tool

is perforce somewhat slender, and to be effective must be held as stiffly as possible; so a special holder that will reach right up to the job is necessary. This holder is constructed like an ordinary standard one with the difference that is out of standard in its dimensions. As the same holder will be required to carry several other tools for the small hole, an adjustable collar is used on the shank of the boring tool to set it to the right distance in the holder when replacing it.

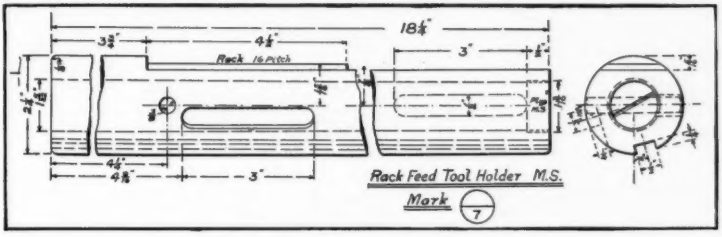


FIG. 6. RACK-FEED TOOL HOLDER.

If the small hole had drawn out of centre as anticipated by the use of the last tool, the centre left by the roughing drill at the bottom of the hole will be eccentric with the trued hole, so the ninth operation is to recentre and bottom the hole with the oil-supplying bottoming tool carried in the same holder as the last tool and set to distance with a similar collar. But, now, a supply from the pump needs to be conveyed to this and other subsequent tools that will be carried in the same holder, and as they must be frequently changed, the means for conveying the oil requires to be somewhat different from that usually provided. Obviously as the holder has a large cavity, which by the usual method of oil supply would become fully charged with oil, considerable inconvenience would result by the copious discharge of oil each time a tool is changed and the delay in refilling the cavity. To prevent this a special plug and pipe is placed up the interior of the holder. A good centre now having been formed at the bottom of the hole, the next drill (No. 21, Fig. 7) with oil supply, is inserted in the same holder to rough out the taper part where the firing pin comes. The tool is then changed for the self-steadying taper oil supply D bit (No. 22, Fig. 7) to perform the eleventh operation, which rough reams the taper hole, the depth being set in the same way as the previous tools.

The final sizing of the small hole and the tapered portion is done by a combination reamer (No. 23, Fig. 7) carried in the rack-feed holder (Fig. 6) held in the special holder. This reamer must be care-

fully fed in by hand to avoid breakage, hence the use of this holder. To facilitate construction the reamer is in two parts, a false nose being fitted to the main portion by a Morse taper. The shoulder between the large and small holder is now radiused with tool held in holder and set to distance with a collar.

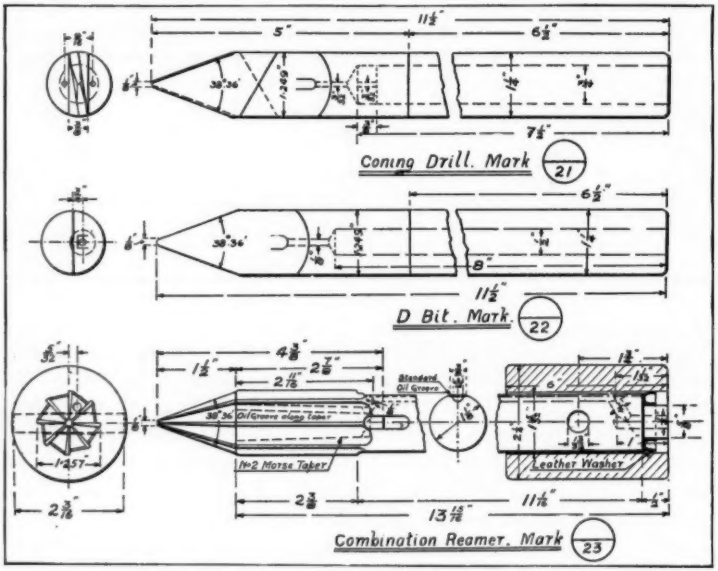


FIG. 7. CONING DRILL, D BIT, AND COMBINATION REAMER.

The fourteenth operation consists in recessing a groove in the small hole at the junction with the taper part, and this calls for the use of a special oil-supply recessing tool (No. 26, Fig. 8) held in a 3-inch standard holder. The groove has to be over ⅛ inch deep and is situated at the bottom of a hole 1¼ inches in diameter at a distance approximately 2 feet away from the face of the turret. To produce such a groove with a long overhanging tool held by a turret that has no traverse motion does not at first sight seem a simple job, yet the tool tackles the work in a very easy manner. The cutting tool itself is held in a spindle that may be rotated through half a revolution by a worm gearing. This spindle is eccentrically supported throughout its length by a fixed sleeve, the eccentricity being a half of the tool movement required, so that as the spindle revolves the cutting point follows the curve of an eccentric circle feeding gradually into its cut. This tool

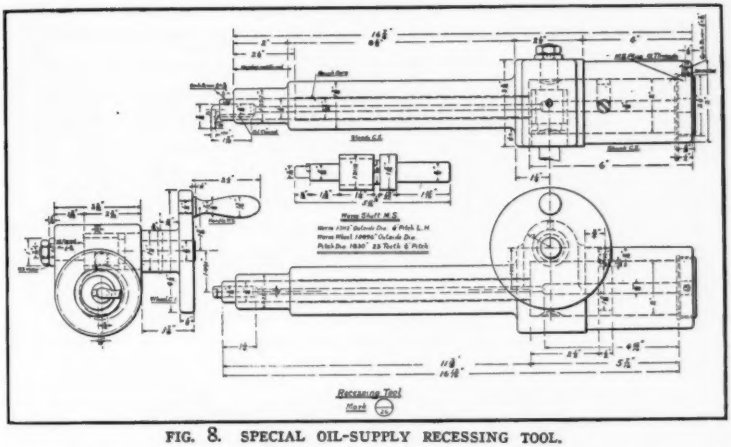


FIG. 8. SPECIAL OIL-SUPPLY RECESSING TOOL.

unless well supported will probably dig in and break, on account of the springiness due to so long an overhang. It is therefore supported by making the fixed sleeve fit the small hole reamed in the twelfth operation.

Oil passes through the spindle and along a groove beside the cutting tool which causes it to impinge upon the cutting edge. It will be observed with all these tools that particular attention has been concentrated upon the supply of oil to the cutting tools as nearly as it is possible to get it to the actual cutting edge; this is necessary, as the steel to be cut is so hard that the tools would quickly give out were this important point omitted.

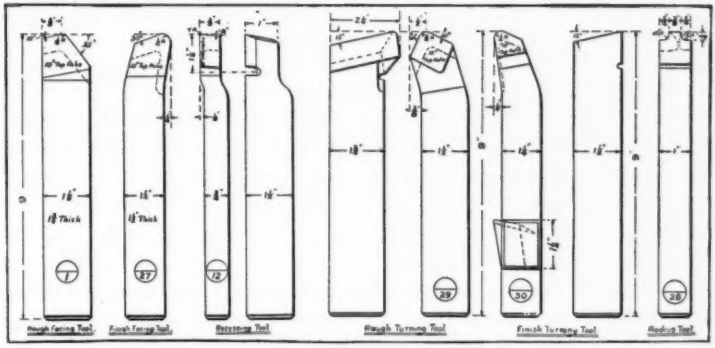


FIG. 9. TOOLS FOR TURNING OUTSIDE FACE AND FLANGE AND FORMING RADIUS ON CORNERS (NOS. 27 AND 28).

Before the first series of operations are finished, the outside face and flange require to be turned and the corners radiused, which is done as the fifteen and sixteenth operations with tools 27 and 28, Fig. 9, held in the square turret. The breech block having been bored and turned so far as is possible at the first setting, now undergoes the second series of operations. As but a very small portion of the outer diameter could be turned at the first setting, there is not sufficient finished surface to grip in the soft jaws of a self-centring chuck. That such a method of holding would be satisfactory is doubtful, even if it were possible in this case; therefore without question it is the right thing to hold the block upon an expanding drawback arbor for the further operation of turning, screwing, etc. Such an arbor with nose

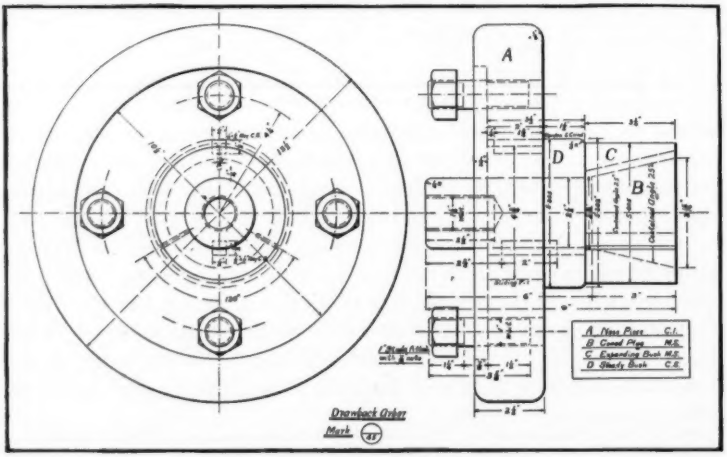
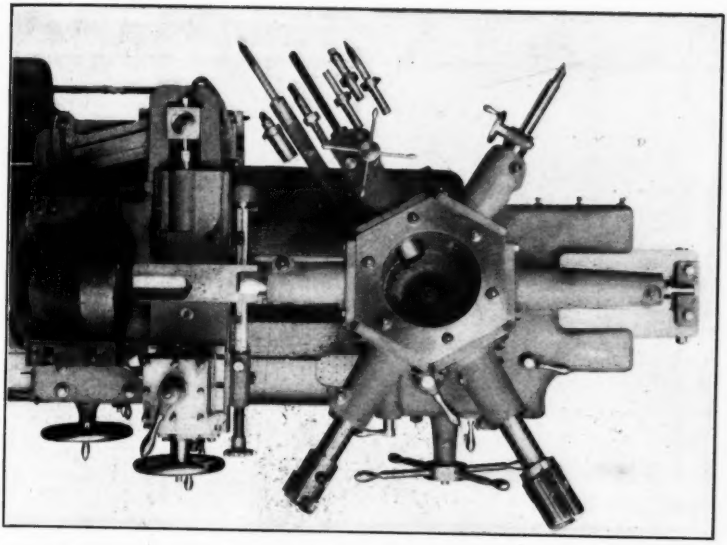
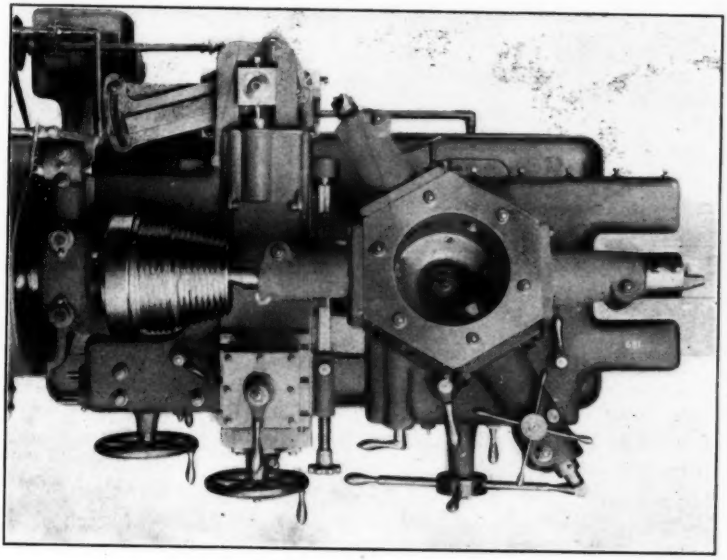


FIG. 10. EXPANDING DRAWBACK ARBOR.

piece, etc., is illustrated in Fig. 10. A cast-iron nose piece A fits upon the spindle end, socketing upon the flange to keep it concentric. Fitting this nose piece there is a cast steel hardened and ground bush D with a shouldered portion projecting one and a half inches in front of the nose piece. This bush is keyed in position so that it revolves with the cast-iron portion, and as it is accurately fitted, the projecting part receives the large hole of the breech block. Within the bush the mild-steel plug B with coned end is free to slide but may not rotate, as there is a preventing feather key, and upon the coned end there is the expanding bush C which expands as the coned plug is drawn towards the nose piece by a bolt through the hollow spindle of the lathe.





FIGS. 11 AND 12. ILLUSTRATIONS OF THE TURRET AND TOOLS SET FOR USE ON BREECH BLOCK OF 6-INCH QUICK-FIRING GUN.

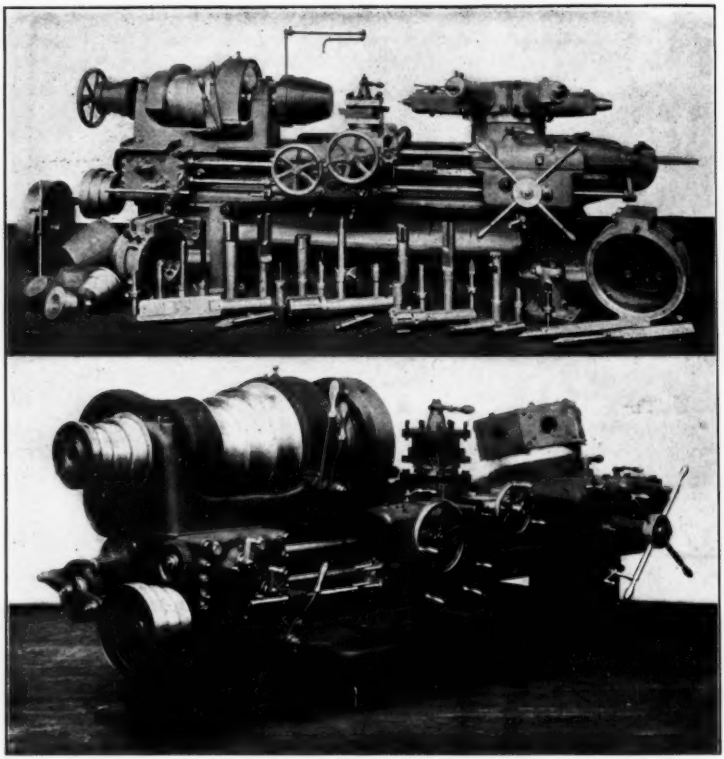


FIG. 13. HEXAGON TURRET LATHE BY MESSRS. ALFRED HERBERT, LTD., COVENTRY, ENGLAND.

After facing the block with the same tool as was used for the first operation it is centered, and the counter-bore is drilled with a tapered flat drill carried by one of the 3-inch standard holders. This type of tool holder is very simple and comparatively cheap to make, so it can frequently be used in turret-lathe work. When the counter-bore has been finished with tool 33 Fig. 14, the remainder of the work in this series of operations has to be done from the square turret.

The third series of operations are all done with the breech block held on the same drawback arbor, and as they consist of a straightforward series with comparatively plain tools to finish, turn, and groove the block and cut the thread, using the taper slide upon the back of the lathe to form the correct taper where required, no further explanation is necessary. In this series of operations it is interesting

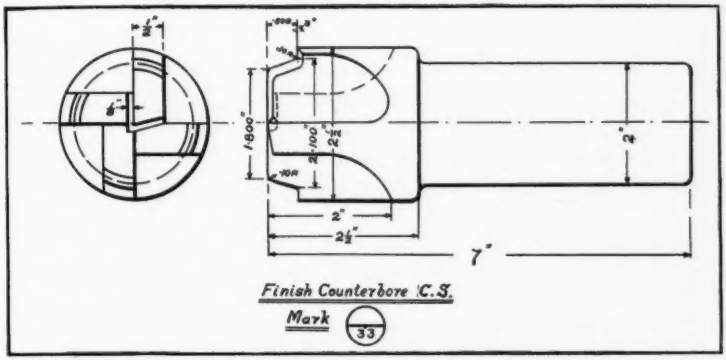


FIG. 14. FINISH COUNTER-BORE.

to note that as more tools are required that can be held in one square turret a second one is brought into service, the work of changing the turrets being quite small as compared with setting and resetting tools.

The last operation is the relieving of the taper thread, for which purpose a specially pitched leader screw, slightly longer in pitch, is brought into requisition. The screws of the breech blocks in question are made with a different pitch on the one side of the thread to that on the other to permit a certain amount of compression or "upsetting" when the gun is fired, the pitch variation being such as is practically found to result in a good bedded fit after firing. Were the thread made an exact fit at first, the compression would probably cause the front threads to take all the pressure after the first firing, with damage to the gun.

In these explanations, the numbering on the tools is in simple sequence for ease of reference in the illustrations and so not in accordance with a system of marking such as has been advocated for the successful location of the tools in stores.

The short space of this article admits of but touching the fringe of so important a subject as the Tooling of Machines, yet perhaps it will serve to show to what extent high-class tooling is being carried at the present day. The degree of accuracy obtainable and the low cost of production can only be realised by those who have successfully followed through such methods of working.

The arrangement of these tools will be better understood by reference to the illustrations on page 793, which are from photographs of the machine with tools set ready for use.

THE MANUFACTURE OF IRON BY ELECTRO-METALLURGICAL PROCESSES.

By Adolphe Minet.

THE metallurgy of iron has attained such a degree of perfection, and makes use of such powerful facilities in the greatness of the capital and equipment involved in it, and in the quantity and variety of the products *, that it seems difficult to grapple with its problems or to realize an economy upon its methods. They can however be attacked from at least one point of view—that of the *cheapest production of the heat-units* necessary both for the reactions and for the power to drive the machinery of the plants for the production and working of the metal.

If some form of carbon is used as reducing agent, the ordinary metallurgists demand further from that element the heat and the power which they want, while the electro-metallurgists make use of natural forces (generally water power) for heat and power, attaining an economy of carbon of about 80 per cent., in the case, for instance, of converting ore into iron or steel. In other words, where the ordinary metallurgists consume two tons of carbon to produce a ton of steel, starting from the ore, the electro-metallurgists use only 400 kilogrammes.

In order to show that the new methods offer an advantage over the old ones, it will be proper, in the first place, to make a comparison in each particular case between the saving attained in the coal and the expenses involved in the installation of natural power (including conduits, turbines, dynamos and electrical connections), its depreciation and maintenance. I say "in each particular case," because the problem cannot be treated in a general manner, by reason of the variation of the price of coal according to the industrial centers considered, as well as of the cost of hydraulic installations; not to mention other very important factors such as the ore and the reagents, of which the price delivered at the works is essentially variable. I shall not concern myself here with the price of the raw materials which enter

* The annual production, in the whole world, is 30,000,000 tons of pig iron and steel; it consumes 60,000,000 tons of mineral fuels, out of the 600,000,000 which are mined every year.

into the metallurgy of iron—a price which is known, or anyhow is easily ascertainable; but I think the reader would be interested by the presentation of some data on the cost of electric heat units, according to the most recent hydraulic installations.

Hydraulic Power and Electric Heat Units*.—The useful electric heat units, that is to say, the heat units developed in the electric furnace itself by the current, are expressed in practice in three different units: (1) in large calories or kilogramme-calories; (2) in kilowatt hours, and (3) in horse-power hours. To simplify comparisons, I shall make use of a single unit, the kilowatt-hour. The values of the others are as follows:

1,000 large calories = 1.16 kilowatt hours = 1.58 horse-power hours.
1 kilowatt hour = 864 calories = 1.36 horse-power hour.
1 horse-power hour = 635 calories = 0.736 kilowatt hours.

In the large hydraulic installations in Europe—3,000 to 10,000 horsepower for example—and with the head varying from 50 to 200 metres or more, the price of a horse-power year, depreciation and maintenance included, ranges between 30 and 70 francs. This refers to the useful horse-power year within the furnaces, that is to say, the electric horse power at the electrodes. I shall adopt the average price, 50 francs. As the effective running is generally 350 days per year and 23 hours per day, say, 8,000 hours, a simple calculation will give for the respective cost of the three units in use: Horse-power hour, 0.63 centimes; kilowatt hour, 0.86 centimes; 1,000 large calories, 1 centime.

With these figures we shall be able to follow readily the descriptions which the electro-metallurgists give us, and to appreciate whether any saving takes place in their processes.

Metallurgy of Iron.—The metallurgy of iron includes three principal phases: (1) preliminary operations; (2) metallurgy proper; (3) working of the metal. We shall see that in each of these parts electricity can be used to advantage.

1. Preliminary Operations.—Leaving out of account native iron, which is met only very rarely, and meteoric iron, the ores of iron

* Let E be the electromotive force of the current, or the difference of potential at the electrodes (entrance and exit), expressed in volts; I the intensity of the current in amperes; g = 9.81 the acceleration of gravity; 75 the mechanical equivalent of the horse-power second; 425 the mechanical equivalent of heat. The useful power, or useful energy of the current, per second, is expressed:—

In watts: W = EI; 1 kilowatt (1,000 watts) equals 102 kilogrammeters.

In kilogrammetres: $Q_k = \frac{EI}{9.81}$; 1 kilogrammetre equals 9.81 watts.

In horse power: H. P. = $\frac{EI}{9.81 \times 75} = \frac{EI}{736}$; 1 metric horse power equals 736 watts.

In large calories: $Q_c = \frac{EI}{9.81 \times 425} = \frac{EI}{4169}$; 1 large calorie equals 4,169 watts.

The useful energy *per hour* is represented by quantities 3,600 times as large.

occur under the following forms: Red hematites, Fe_2O_3; magnetic iron, Fe_3O_4; brown hematites, $Fe_2O_2(HO_2)$; iron pyrites, FeS_2, employed only after having been used in the manufacture of sulphuric acid; spathic iron, $FeCO_3$; and vivianite, $Fe_2(PO_4)_2$, which has little importance for the industry with which we are concerned. Before undergoing metallurgical treatment the ores are submitted to one or several preliminary operations, according to their nature:

(a) Mechanical working, consisting of a simple coarse crushing of the lumps of ore which are too large, and of a washing to remove the sand and clay which occur mixed with the ore. Here hydraulic installations offer every advantage—cheap power and water at will.

(b) Roasting, for the purpose of transforming spathic iron or magnetic iron, for example, into the more readily reducible peroxide. Here again the electric calories furnished by natural power are more economical than the calories set free by the combustion of coal.

(c) Magnetic preparation, for ores containing iron or the magnetic oxide of iron; here again the advantages are all in the use of water power for putting in movement the apparatus of separation and producing the powerful magnetic fields.

2. Metallurgy Proper.—The methods of treatment of the ores for obtaining the metal, cast iron or steel, may be divided into two main classes: (1) the direct method, or method furnishing the metal in a single operation, by direct treatment of the ore; by this method the cast iron, wrought iron and steel are obtained extra soft; (2) the indirect method, or method of two parts—conversion of the cast metal, cementation of the wrought iron and cast metal. The accompanying table of these different methods shows for each one of them the state and the nature of the products, as well as their method of operation.

Direct methods.	Pasty metal.	Iron; steely iron.		Catalan forge.
	Liquid metal.	Cast iron.		Blast furnace.
Indirect methods.	Solid metal.	Cementation steel.	Decarburation of cast iron.	
			Carburation of wrought iron.	
	Pasty metal.	Wrought iron.	Conversion of cast iron.	"Feu Comtois."
				Low hearth.
				Puddling.
	Liquid metal.	Steel.	Simple Fusion; Crucible.	
			Conversion of cast iron. (Converters.)	Bessemer.
				Thomas and Gilchrist.
				Robert.
			By reactions.	Martin. Siemens. Acid.
				Basic.
				Neutral.
				Perrot, with removable and rotary furnace.

I shall preserve this classification for distinguishing the electro-metallurgical methods; but I may say at once that except as far as the cementation processes are concerned, which in view of their principle necessarily proceed by the indirect method, electro-metallurgists have every interest in adopting in other cases the direct method, with which they obtain at will, in the same apparatus, all grades of cast irons, wrought irons and steels.

3. Working of the Metal.—Without entering into details of this phase of the metallurgy of iron, it can be seen that a great saving will be attained by the use of natural forces to set in motion the powerful machinery necessary for this work. In this also, electricity can perform important services; among other things, several processes of electric welding are known and have received the sanction of good practice.

Electro-metallurgy of Iron.—It can be said in a general way that electro-chemical methods differ from the processes of ordinary metallurgy, either in the arrangement of apparatus, or in the mode of operation; and that, as compared with these latter, they have the advantage of utilizing one of the characteristic properties of electricity—the *power of accumulating in a very restricted space a very large quantity of energy.* If it is borne in mind that by reason of this accumulation of energy the losses are reduced to a minimum, and that by making use of natural forces the calorific energy necessary for the reactions is obtained at the lowest price, it will perhaps be deemed interesting to follow the evolution of the new methods and to know their actual status. They are divided, as metallurgical methods, into two classes: (1) direct methods, and (2) indirect methods.

Direct Methods; Stassano Processes.—Mr. Stassano has invented two types of apparatus for the electro-metallurgy of steel by direct method, that is to say, starting from the ore, and without passing through casting.

First type: The first of these arrangements, to which Mr. Stassano gives the name of electric blast furnace * is represented in Figure 1. It is arranged for heating the reaction chamber by the electric arc. The first trials carried through by that engineer gave so much hope from the start that it was possible to form a company immediately, and to install in the valley of Camonica, in the Bergamese Alps (Upper Italy) three electric blast furnaces of 500 horse power each, with a view to the treatment of the iron ore of the country, and with a total annual production of 4,000 tons.

* English patent. No. 11,604, 1898.

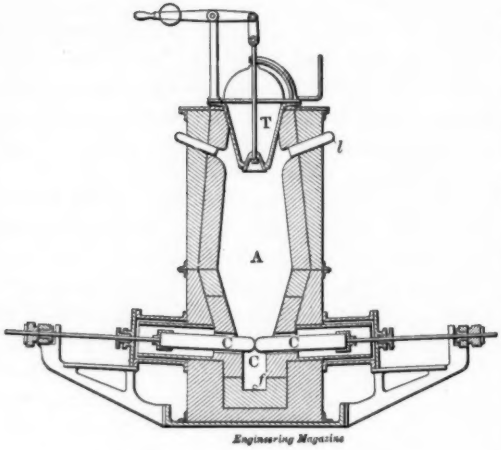


FIG. 1. ELECTRIC BLAST FURNACE, STASSANO SYSTEM.

The ore, prepared as described below, is charged into the shaft, A, by means of the hopper, T; it is melted by the electric arc burning between the electrodes, C C; from the crucible, C, the iron and the slag run out at f. The ores—oxides or carbonates—are first pulverized and subjected to an electro-magnetic preparation for increasing their contents of iron; the carbonates are completely calcined. The quantity of carbon necessary for the reduction, as well as the quantity of fluxes to be added for the scorification of the gangue contained in the ore, are calculated according to the analysis. The quantities of carbon, lime and silica thus determined are pulverized and mixed with the enriched ore. After having added also about 5 to 10 per cent. of tar as an adhesive, the mass is subjected to a pressure of 200 to 300 atmospheres, and, thus bound together, it is broken into fragments which are then

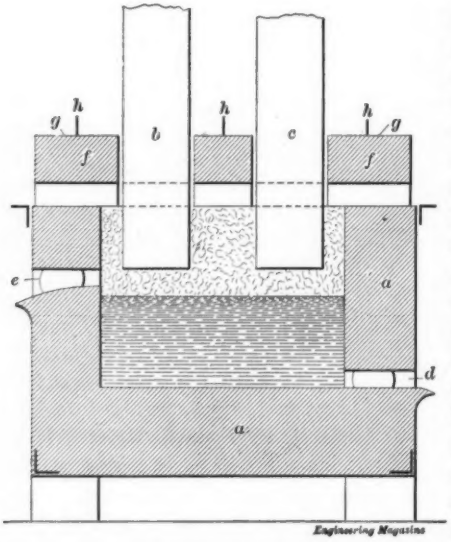
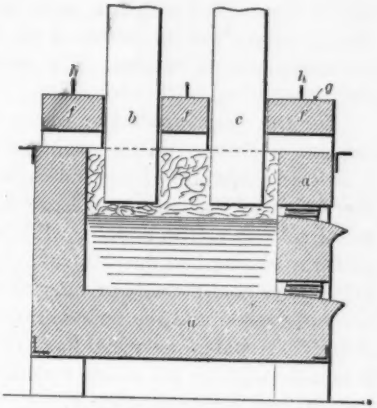


FIG. 2. HÉROULT FURNACE, TYPE I.

charged into the blast furnaces. At the temperature which rules in the chamber where the electric arc is burning, the sesquioxide of iron is reduced by the carbon mixed with the ore; and the metal resulting from this reduction, and containing more or less carbon, collects in the crucible. The foreign elements pass into the slag, which can be let out by a special opening.

According to Mr. Stassano, it is possible with powerful furnaces to succeed in producing a ton of steel at a cost of 3,100 horse-power hours (or their equivalents, 2,282 kilowatt hours, 1,969 thousands of calories), costing 19.69 francs, and replacing 1,500 kilogrammes of coal at 29 francs a ton, say, 45 francs. By the fact of using electric calories, a first saving is attained of 25 francs per ton of steel produced.

Frages-Héroult Processes. —Héroult, to whom we are indebted already for several applications of electro-metallurgical industry, was one of the first to study the electro-metallurgy of iron, and he established several types of electric furnaces, which are being exploited in France and in Sweden.



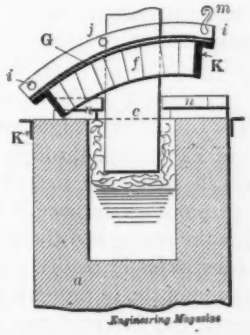


FIG. 3. VARIATION OF HÉROULT FURNACE, TYPE I, AND

FIG. 4. TRANSVERSE SECTION OF HÉROULT FURNACE, TYPE I.

First type*: The first apparatus applied on a large scale to the electro-metallurgy of iron by Héroult dates from 1900. The characteristic of this method is the fact that one can obtain at will all varieties of cast iron, wrought iron and steel, of all states of carburation, in the same apparatus, and if one wishes, in the course of the same

* French patent, No. 305,317. Société Electro-Métallurgique de Frages.

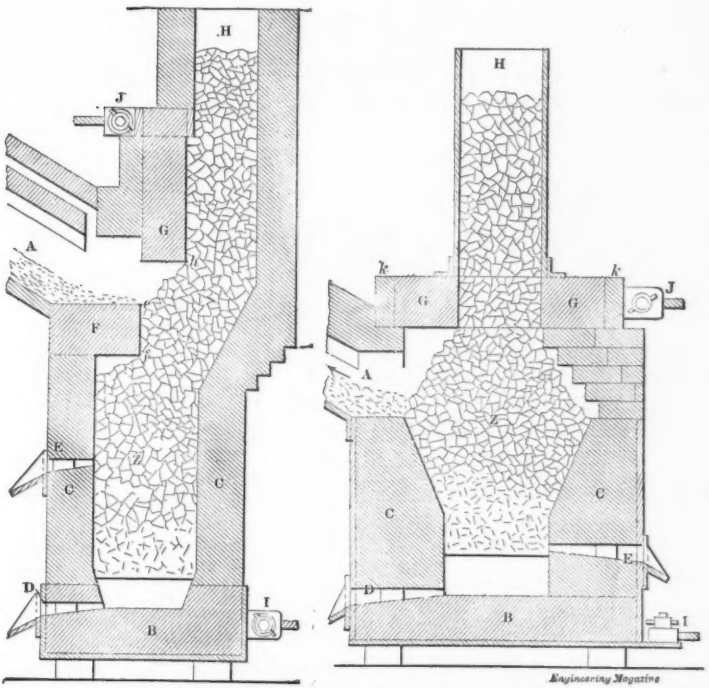
operation. Figure 2 shows a vertical longitudinal section of this furnace. Figure 3 shows a variation from it, in which the two outlet holes are upon the same face of the crucible. Figure 4 exhibits the crucible open for charging (transverse vertical section). The furnace consists in its essential parts of a crucible, *a*, in which the electrodes, *b*, *c*, dip; it is provided with two outlet holes at different levels; the lower one, *d*, serves for the outlet of the metal; the other is designed for the evacuation of the slag. The metal to be worked is kept sheltered from the carbon of the electrodes.

For the direct production of the metal, starting from the ore, the crucible is charged in the ordinary way, by casting into the bottom a little of a mixture of ore and carbon in suitable proportions. Under the action of the current the ore melts and is reduced; the heavier metal collects at the bottom, while the slag accumulates above. As soon as the slag becomes obstructive, it is run off by the upper outlet hole, either continuously or intermittently. According to the proportions of carbon and the temperature, one can obtain at will soft iron in the pasty state, or a metal more or less carburated. This apparatus is equally suitable for indirect methods. For example, for the treatment of cast iron and of scrap.

Second type *: The second apparatus, called *electric furnace with fluid electrode,* is designed in such a manner as to treat ores previously melted or pasty, or sufficiently softened to descend progressively in the shaft of the furnace in which the reaction takes place. The shaft, with refractory lining inside, contains a column of coke of convenient height, or of any other fuel which is a good conductor of electricity, through which passes an electric current, and with which mixes the melted or pasty ore introduced from an adjacent preparatory furnace, which also acts by electricity. The fuel, by which the passage of the current for the reduction of the ore takes place, constitutes in reality one of the electrodes; it flows in the furnace continuously, in proportion as the operation proceeds.

Héroult has invented two variations of the same type. Figure 5 is the section of a furnace which is especially suitable for the production of cast iron, wrought iron, ferro-silicon, ferro-manganese and other similar products. A carbon crucible, B, is surmounted by a refractory masonry, C, which is designed to contain the active part of the column of carbon, and also the slag. The crucible, B, is pierced by an outlet hole, D, for the melted metal, and the stack or jacket, C, has a hole, E, for the slag. The latter may occupy a quite different

* French patent No. 318,638. Société Electro-Métallurgique Française de Frages.



FIGS. 5 AND 6. ELECTRIC FURNACE WITH FLUID ELECTRODE, AND VARIATION OF THE TYPE.

point of the periphery of the trough. The terminals from the source of electricity are connected on the one hand to the crucible B at I, and on the other hand at J to the block G, against which the fuel rubs in flowing or descending in the stack. Figure 6 represents a variation in which the crucible, C, is preferably of carbon, and the column of coke, Z, makes contact on the one hand with the carbon crucible, B, and on the other hand with an upper conducter, G, of carbon. In both cases the hot gases proceeding from the reaction escape in the adjacent preparatory furnace.

Harmet Process.—Figure 7 gives the set of apparatus invented by M. Harmet for the purpose of making cast iron, wrought iron, or steel directly from the ore. This set includes three principal parts, each one corresponding to one phase of the treatment; a first apparatus in A, for the fusion of the ores; a second one in B for the reduction; and a third one in C for the further treatment of the metal. It is the

regulator of the Martin electric furnace. The two first ones, A and B, are continuous in running and production. The third, C, is continuous in its operation, but it is tapped repeatedly, allowing the accumulation of the metal produced so as to give a large quantity at once.

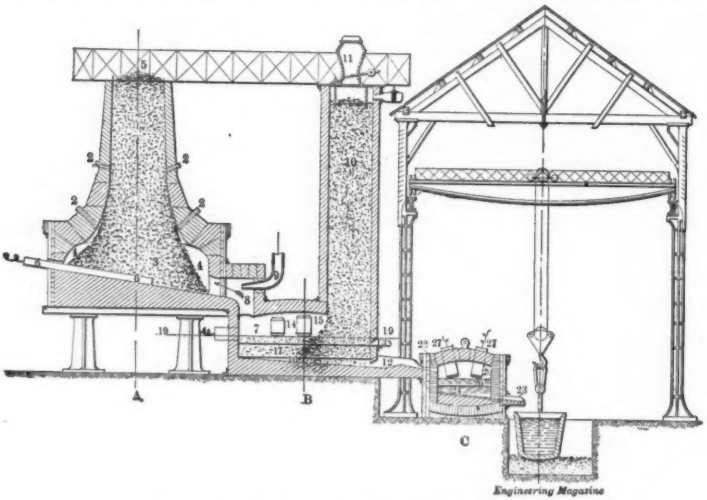


FIG. 7. GENERAL VIEW OF HARMET APPARATUS.

The regulator represented in the set of three apparatus is also reproduced in detail in the three following figures; Figure 8 is a section through the entrance channel from the reducing apparatus and the outlet hole. Figure 9 is a plan.

M. Harmet has made a comparison, from the point of view of economy, between his process and those actually used for the manufacture of steel, assuming that the coke costs 25 francs per ton, and the coal the same, and that 1,000 electric calories cost 1 centime. In the triple furnace he counts upon producing one ton of steel, finished, with 3,200 horse-power hours (which are equal to 2,344 kilowatt hours, or 2,025 thousands of calories), which involves an expense of 20.21 francs per ton of steel produced. These are substantially the same figures as those of Stassano, and the economy attained by the use of electric calories, as compared with the use of steel, would here also be 25 francs per ton.

Keller Process.—We have again a case of the direct production of steel; the whole system, which calls to mind the Harmet process as to its general arrangement, consists of two furnaces arranged in series.

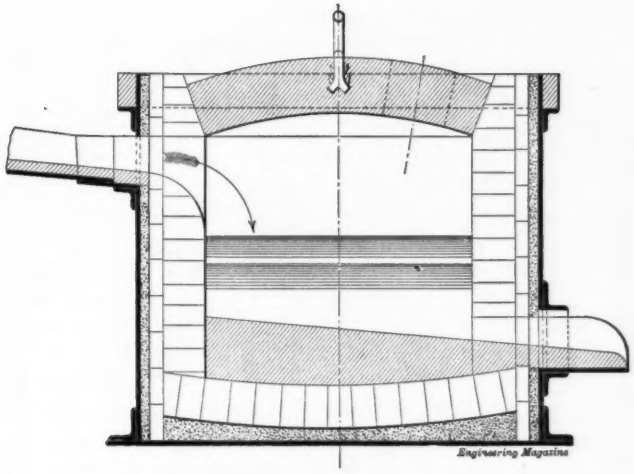


FIG. 8. SECTION OF HARMET REGULATOR THROUGH THE ENTRANCE CHANNEL AND THE OUTLET.

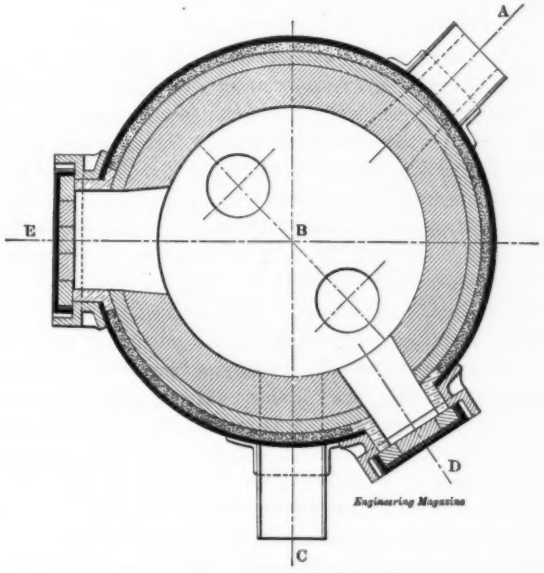


FIG. 9. PLAN OF HARMET REGULATOR.

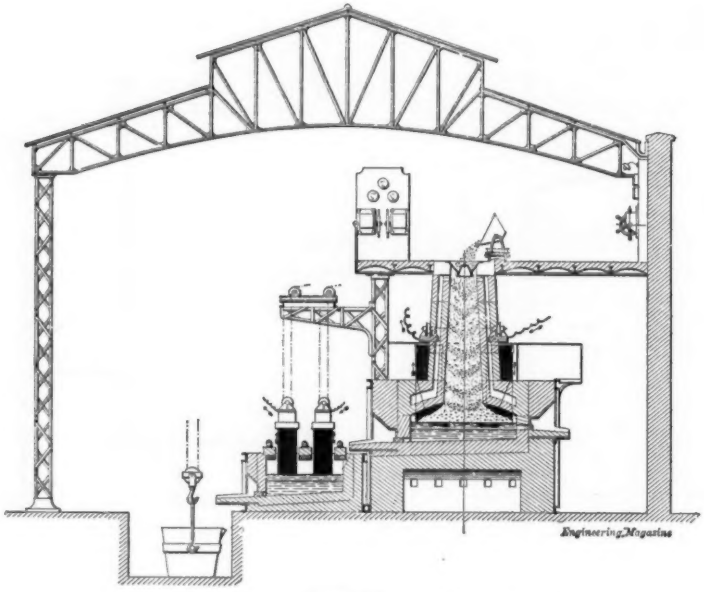


FIG. 10. KELLER ELECTRIC BLAST FURNACE.

The upper furnace (Figure 10) contains two groups of two vertical electrodes each, the two electrodes of the same group being connected in parallel, and the two groups in series. These four electrodes are placed in the same vessel with refractory walls. The body of the furnace is inclined towards the outlet hole. It is constructed in the same manner as the body of the Martin furnace. Under the outlet hole of the upper furnace the conversion furnace is set up. This latter consists of a movable refractory vessel, which serves simply as a receptacle for the molten metal. This receptacle is closed by refractory covers, which can be removed, and within it two vertical electrodes can be raised or lowered by means of a lifting mechanism controlled by hand. The furnace is closed in the manner usual in blast furnaces.

As soon as the upper furnace is started running the materials are introduced through the furnace top, and fill the furnace. The reduction of the metal and the fusion of the ore begin to take place only in the body of the furnace. After some time of running the carbon monoxide and the ore are sufficiently hot to react. From that time on the reaction takes place not only in the lower part of the furnace, but also in the region of fusion. After some hours of running the raw

metal is run out into the conversion furnace, which has been previously warmed and already contains melted matter. Soon afterwards the upper furnace is emptied of slag, by one of the special side taps.

M. Keller built an electric blast furnace at the Kerrousse works, near Hermebont (Morbihan). It produces a ton of steel with 3,800 horse-power hours (or their equivalents, 2,797 kilowatt hours, or 2,413 thousands of calories); that is to say, at a cost of 24.13 francs per ton of steel produced, thus attaining an advantage of 21 francs per ton, as compared with the use of coal as source of heat. It will be noticed that the figures given by MM. Stassano, Keller, and Harmet are in very good agreement.

Process of Chavarria Contardo.—This engineer has taken out a series of patents bearing upon the electro-metallurgy of iron. In the first patent he claims: (1) a continuous electric furnace, utilizing the whole of the heat produced by the voltaic arc, which is entirely surrounded by the raw materials treated, but without ever being touched by them; (2) a continuous electric furnace in which, independently of the heat produced by the electric arc, use is made also of the entire heat produced by the gases resulting from the chemical reactions, whose combustion in the interior of the furnace is brought about by the introduction of a gas tending to produce combustion; (3) in another furnace, the use of two different materials; ordinary refractory masonry, and material of extra refractoriness or cooled by the circulation of a fluid, in order to permit the furnace to support both the high temperatures produced electrically, and the chemical and mechanical actions due to the introduction of the air; (4) in a fourth class of furnaces special arrangements by means of which the electric arc can be sunk in the material to be treated, without ever coming in contact with it.

In a second patent * M. Chavarria Contardo describes a reverberatory furnace, for continuous operation, heated by electricity.

The third patent † describes: (1) a method of preserving the electrodes outside of the furnace; (2) the possibility of introducing the current at a fixed point, the electrodes moving backwards and forwards as needed, under the action of a regulator controlled by an independent current (3) the complete utilization of the electrodes, without their depreciation.

The fourth patent ‡ describes a continuous electric furnace with closed front, itself supplying its own current through utilizing the

* French patent No. 197,777, March 2, 1900.
† French patent No. 197,777, March 2, 1900.
‡ French patent No. 299,490, April 20, 1900.

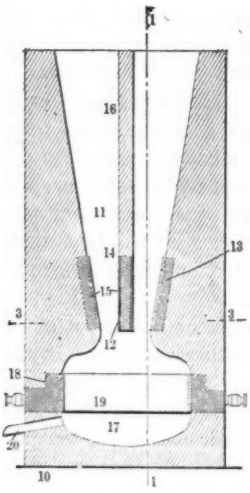


FIG. 11. CONLEY FURNACE.

gases set free in the reactions, by means of a gas engine driving direct or alternating-current dynamos.

Conley Furnace.—This is a resistance furnace, arranged for producing the steel by the direct method. The mixture of ore and carbon is melted and brought into contact with resistances raised to a very high temperature by the passage of an electric current. The furnace inside is constructed in the form of an inverted cone. The crucible which terminates it at the bottom is very large. It has about the same diameter as the largest section of the cone (Figure 11). In the narrow place formed at the point of the inverted cone the wall is made of plates of high electrical resistance. The cone is divided into two perpendicularly by a wall, which in the narrow part also ends in plates of poorly conducting materials. These plates are made of a mixture of clay or refractory earth with retort carbon or graphite. The crucible is surrounded horizontally by a belt formed of a certain number of plates. The rest of the furnace is constructed of refractory brick. The ore, to which carbon has been added, is introduced and melts when it comes into contact with the resistance in the lower part of the furnace, above the crucible. The metal and the slag run into the latter, where they are maintained liquid. The metal can be treated in the crucible as in an ordinary furnace; in short, it can be transformed into steel.

To produce 100 tons of steel in ingots by the Conley process would require the consumption of 5,000 horse-power days, or 120,000 horse-power hours of electrical energy; that is to say, the consumption for the production of one ton would be 1,200 horse-power hours, or their equal, 843 kilowatt hours, or 762 thousands of calories. These figures are much lower than any of those given before; and, pending more definite information, I question their correctness. I think that in the present state of affairs one must assume an expenditure of 3,000 to 3,500 horse-power hours to produce a ton of steel by the direct method.

Adolphe Minet's Furnace.—I have proposed a furnace system *

* French patent. Adolphe Minet, December 2, 1899.
* German patent, Minet-Neuberger, 1901.

for the purpose of economically applying electro-metallurgical processes in works that are distant from any natural power, but that use cheap sources of heat, such as low-grade gas, gas from blast furnaces, etc.

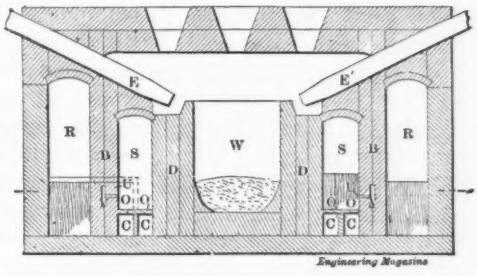


FIG. 12. LONGITUDINAL SECTION OF MINET FURNACE.

The furnace depends upon the separate or simultaneous utilization of three sources of heat, according to the temperature of the reaction: blast-furnace gases, either in combustion or not in combustion; poor or rich gases coming from gas works; and electricity in the form of current passing through the materials treated, or in the form of the electric arc. In connection with gas engines driven by the gas from blast furnaces and furnishing the motive power for dynamos, it ensures in iron works, for example, the application of most electro-metallurgical processes under conditions of economy of the same order as those attained in works driven by natural power.

The furnace consists of a central chamber, W (Figures 12 and 13, longitudinal vertical section and longitudinal horizontal section), supplied with an outlet hole, T, and separated from the heating chambers, SSSS, by partitions, DDD, of which the nature varies according to the reactions and the products of the reactions. The heating chambers SS receive through the holes OO either blast-furnace gases from the flues CC or rich or poor gases from the flues C'C' coming from a gas producer or gas works; and these gases burn in the chambers SS. These chambers are separated from other

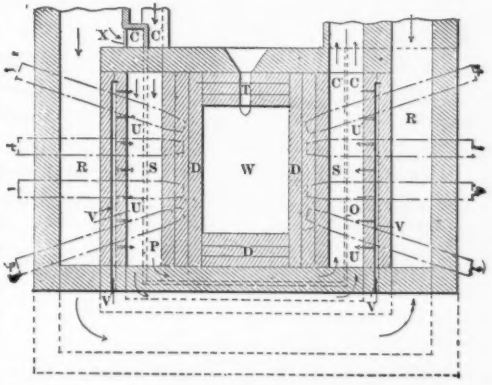


FIG. 13. HORIZONTAL SECTION, MINET-NEUBURGER FURNACE.

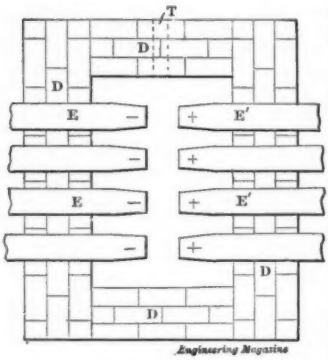


FIG. 14. ELECTRODES OF MINET-NEUBURGER FURNACE.

reheating chambers RR by partitions BB, of refractory clay, in which are built flues U opening into the combustion chambers SS by air holes, V. The reheating chambers RR are traversed by the blast-furnace gases, of which a part enters into the flues CC, which are provided with a regulator X, for controlling the quantity of gas which should pass into these flues. This part burns in SS; the greater part of the blast-furnace gas passes unburned from RR and is used for supplying the gas engines. The electric current is conducted by the electrodes EEE'E', which in the various cases take the positions represented (Figures 13 and 14). It is possible also to conduct the blast-furnace gases to the center of the reaction at VV, and to take advantage of their reducing properties or to burn them directly above the raw materials.

With a furnace of this kind it is possible to obtain every temperature from 200 degrees to 900 degrees (centigrade) by using the blast-furnace gases alone in combustion or not in combustion; from 900 degrees to 1,300 degrees by using the blast-furnace gas with other rich or poor gases; and from 1,300 degrees to the temperature of the arc, by adding to these different sources of heat the action of the electric current.

Ruthenburg Furnace.—The *Iron Age* published a short time ago some data regarding this apparatus, which can be used for two purposes. It may serve simply for the agglomeration and concentration of ores of iron, or also for the reduction of ores.

It consists (Figure 15) of a horizontal magnet in the form of a horse shoe, mounted upon a support, about which it can turn. The magnet is fastened upon the support by means of a hinge, and this hinge is insulated. The cylinders BB' can be brought near to one another or separated by means of a screw placed behind them, of which the points of attachment are insulated. The pole pieces, which are of cast steel, have the form represented in the section, and produce an intense magnetic field. The cylinders, concentric with the branches of the magnet, turn in bronze blocks. These blocks are covered with a coating of carbon, forming electrodes, and are water-cooled.

As already said, the apparatus can fulfil two functions: The agglomeration of iron ore, if carbon is not added to the ore; or also the partial reduction of the ore, if carbon is added. The charge is introduced automatically upon the upper part of the cylinders, and the magnet holds it in contact with them while they turn. An arc is formed at the place where they are nearest together. At that point the charge is rendered incandescent, and the reaction takes place.

Most of the arrangements described under the present heading can serve equally well for the preparation of the metal by the indirect method.

Indirect Methods; Process of Hillairet and Garnier.—* The process of Hillairet and Garnier forms an experiment rather than a real application. These engineers wished to prove that it was possible to produce easily by the use of electricity as calorific agent, a cement steel of a definite degree of hardness. In a refractory tube are placed end to end a stick of carbon and a rod of iron containing 0.1 per cent. of carbon, in such manner that the ends in contact are about the middle of the tube. The whole is heated in a little blast furnace. During the heating a suitable continuous current is passed through the two rods, from the carbon to the iron. At the end of three hours the iron rod is withdrawn suddenly from the tube, and cooled by immersion in water. The end of the iron rod which was in contact with the stick of

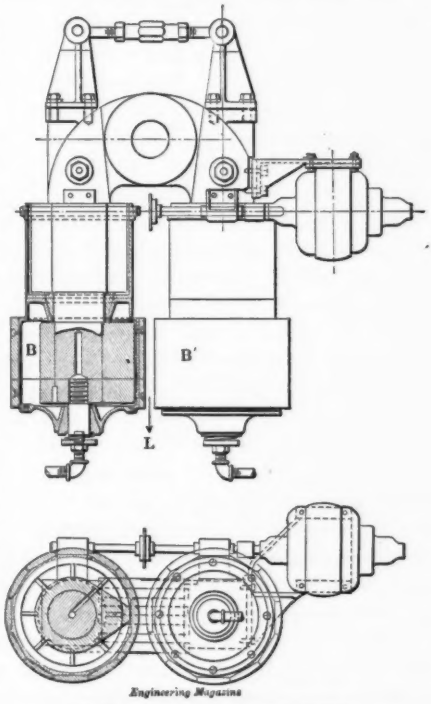


FIG. 15. FURNACE OF RUTHENBERG, OF PHILADELPHIA.

* Nernst-Borchers, *Jahrbuch für Elektrochemie für* 1894. Halle 1895; *Engineering and Mining Journal* (New York), v. 57, P. 57, 1894.

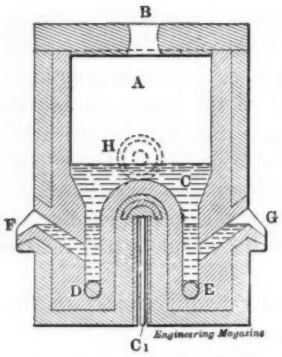


FIG. 16. LAVAL FURNACE.

carbon is hardened to a depth of ten millimeters to such an extent that it scratches glass.

By reversing the current in another experiment it is proved that the cementation is due to the transfer of carbon into the iron by the action of the current. In this case the iron rod, through which the current now enters, remains almost unchanged.

Laval Process.—The author of this process has proposed the replacement of the blast-furnace method by a process of electric fusion.

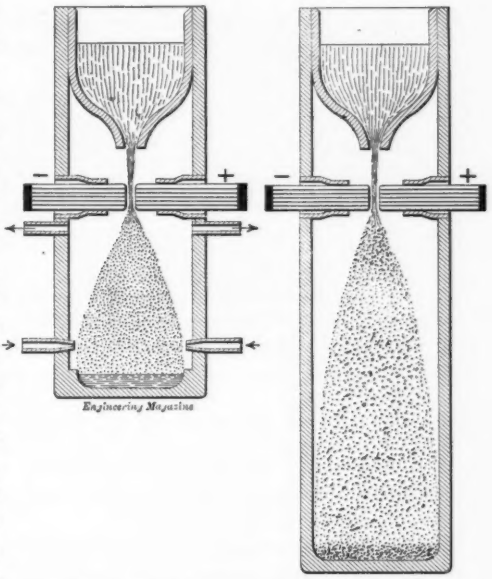
He recommends,* in the first place, roasting the ores of iron, with the ordinary fluxes, to reduce them, without letting them reach the point of fusion. The fusion is effected afterwards in a furnace represented in Figure 16. The working is separated into two compartments by a bridge C, supplied with cooling arrangement C′. In these two compartments two electrodes D and E are arranged; by the opening B, a molten bath (fluxes and magnetic iron) is let in upon starting the current. The resistance of the bath should be so great that the heat developed by the passage of the current maintains fusion. To prevent the bath from decomposing by electrolysis, an alternating current is used. The metal, introduced into the furnace by the opening B, descends to the bottom of the bath, is melted there, and collects in the two polar compartments until it attains a sufficient height to run out by G or F. The bath or the slag is maintained at the same height by the tube H. The cooling apparatus consists of a hollow, flat metallic body provided with two openings, by which the refrigerant enters and leaves.

The author does not make any statement as to the nature of the metal produced, whether it is cast iron or steel. It is to be observed, besides, that his apparatus is a furnace for fusion rather than for reactions; and that, unless in applying the cheaply produced electricity also to the reactions, the Laval process does not seem to offer any important advantage over the ordinary metallurgical methods.

Gérard-Lecuyer's Process.—The process of Gérard-Lecuyer dates from 1895; it depends, like the method of the Bessemer converter, upon the transformation of cast iron into steel by oxidation; but

* *Engineering and Mining Journal*, v. 57, p. 509, 1894.

while in the Bessemer process the quantity of air introduced at each instant into the interior of a large mass of molten cast iron is very small, in the process of Gérard-Lecuyer, on the contrary, it is the quantity of molten cast iron which is in the minority; it is introduced, in a finely divided state, into the presence of a considerable amount of air, so that the oxidation of the cast iron can take place instantaneously. The nature and the fineness of the steel obtained in this manner would be governed by varying the fineness of division of the metal, or the duration of contact of the globules of molten cast iron with the air. The raw cast iron is turned directly from the cupola into the upper receptacle, from which it flows in the incandescent state and with a definite velocity across two electrodes, between which an arc is burning. The great heat of the arc raises the molten cast iron at the moment of its outflow to such a temperature that the mere exposure of the globules to the air (Figure 17), or the mere blowing of the air into the metal (Figure 18), are sufficient to eliminate the oxidizable bodies contained in the cast iron.



FIGS. 17 AND 18. GÉRARD-LÉCUYER FURNACE, TYPE 1 (ON THE RIGHT) AND TYPE 2 (ON THE LEFT).

Some of the numerical results obtained in practice are as follows: 5 kilogrammes of melted cast iron take 55 seconds to flow past the electrodes; the constants of the current being 30 volts and 800 amperes, the corresponding consumption of energy is 0.48 horse-power hours. Thus 10.4 kilogrammes of cast iron are converted per electric horse-power hour consumed; or one ton per 100 horse-power hours, approximately. It must be mentioned that these figures do not include

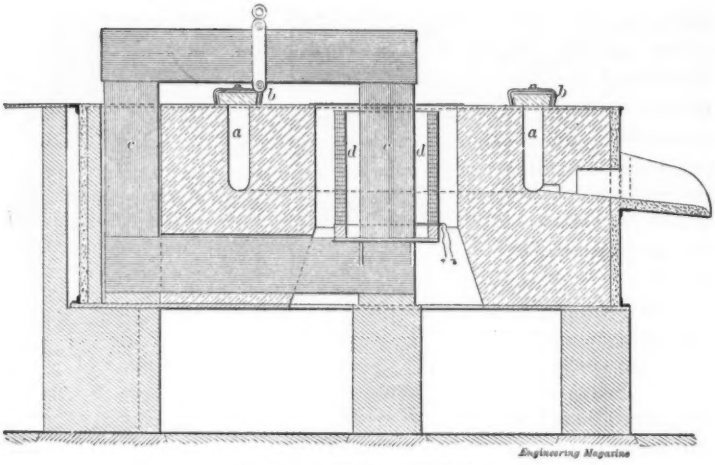


FIG. 19. KJELLIN FURNACE.

the expenditure of energy for melting the cast iron, nor for reheating and melting the steel produced.

M. Gérard-Lecuyer was to have made some changes in this first arrangement, the nature of which I am not able to state.

Kjellin Furnace.—Designed for the production of steel from cast iron. It has the peculiarity of operating with electrodes (1).

A ring, *aa* (Figure 19), of which the sides and the bottom are made of refractory brick, forms the chamber of the furnace, which is closed by the plates, *bb*. At the center of the furnace is placed a core, *c*, made of steel plates insulated from each other. This core is surrounded by a coil, *dd*, of insulated wire, and is continued from the other side of the ring, forming a rectangle.. The terminals of the coil, *dd*, are connected to the terminals of an alternating-current dynamo. When the current passes through the coil, an alternating magnetic flux is produced in the core; this flux induces an alternating current in the ring formed by the metal contained in the furnace. The ring having but one turn about the core, the current induced in it is nearly equal to the current from the dynamo multiplied by the number of turns of wire of the coil, *dd*.

Some interesting experiments were made upon this furnace, * by varying its dimensions, in the course of the year 1900. The first furnace consumed 78 kilowatts, and produced 270 kilogrammes of steel

* Furnaces without electrodes date from a few years ago. Besides that of Kjellin, there are the furnaces of Schneider, of E. A. Colby, and of Ferranti.

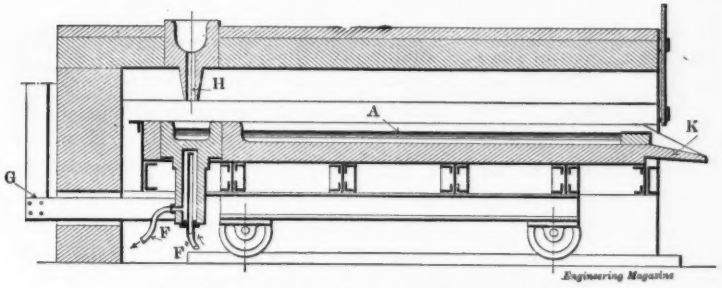


FIG. 20. LONGITUDINAL SECTION OF GIN FURNACE.

in 24 hours; a second furnace reached a production of 600 to 700 kilogrammes in the same amount of time. Finally, a third apparatus, absorbing 330 kilowatts of power, gave one ton of steel at an expenditure of 828 horse-power hours, or their equivalents, 609 kilowatt hours, or 526 thousands of calories. These are nearly the same numbers as those found by M. Gin, as we shall see later, in starting from molten cast iron at 1,300 degrees centigrade. In order to take into account the heat absorbed in melting the cast iron and in raising its temperature to 1,300 degrees, the above figures must be doubled; we have thus finally: 1,656 horse-power hours, 1,212 kilowatt hours, or

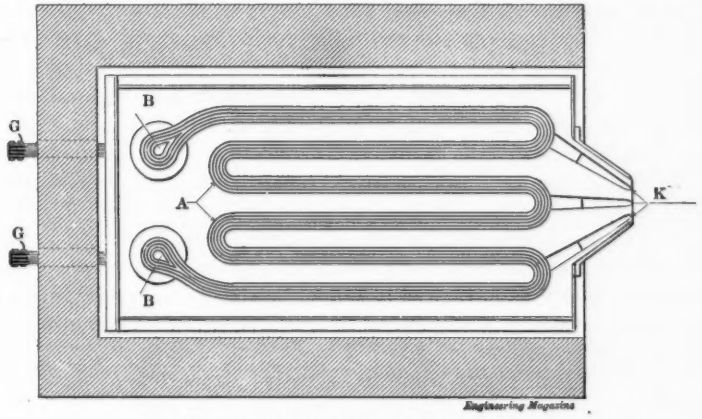


FIG. 21. HORIZONTAL SECTION OF GIN FURNACE.

1,052 thousands of calories. The expenditure of energy in the indirect method would accordingly be only half of that necessary in the direct method; but in view of the cheapness of the energy, this constitutes an advantage of only 10 francs in favor of the former method. On

the other hand, the direct method has the benefit of the much greater difference between the cost of the ore which it uses and the cost of the cast iron which forms the raw material of the indirect method.

Gin's Furnace.—This furnace (Figures 20 and 21) comprises as its essential parts a canal of great length and small cross section, *A*, which is filled with melted cast iron, and of which the ends are connected to blocks of steel cooled by an interior current of water, F. The passage of an electric current of suitable intensity in the conductor consisting of the molten metal sets free a quantity of heat sufficient to maintain the whole mass in fusion, and to raise it to the temperature most favorable for the production of reactions of conversion. On the other hand the rather large cross section of the blocks, G, H, forming the ends of the circuit, prevents the passage of the current from producing there too high a temperature, which is further limited by water circulation.

For the conversion the method by dilution ("scrap process") may be applied by adding to the cast iron a calculated amount of scrap, which dissolves in the liquid bath. It is also easy to use the method of oxidation by the ore ("ore process"). The oxygen of the iron oxide added to the bath burns the silicon, manganese and carbon; the carbon is eliminated the more rapidly the higher the temperature.

With the ore process M. Gin obtains one ton of steel by consuming 567 kilowatt hours, the power used by the furnace being 300 kilowatts. With the scrap process, using double the above power (600 kilowatts), the electric energy necessary to produce one ton of steel would be 631 kilowatt hours. It will be noticed that the figures given by M. Gin are virtually the same as those given by M. Kjellin.

Conclusion.—As may be judged from the present study, the efforts made by electro-metallurgists have already been considerable, and their enterprise deserves to be taken into consideration seriously; they have also to their credit the easy and economical production of the whole series of alloys of iron or steel with silicon, manganese, chromium, tungsten, titanium, and nickel, which require from metallurgists a consumption of coal double and sometimes triple that required in the metallurgy of iron.

Some of their plants are in full activity; among others, those, for instance, of the Société E'lectro-métallurgique de Frages, in France (Frages-Héroult process), those at La Praz (Savoy), at Frages (Isère) and in Sweden, where they are competing with the Kjellin process. I may add that they are already furnishing to the industries by hundreds of tons irons and steels of all kinds, and iron and steel alloys of every nature.

EDITORIAL COMMENT

LABOR affairs have demanded and received a large share of public attention during the past few weeks —"labor," that is, in the technical sense, in which it means a hierarchy of professional representatives, not always very wise or reasonable, to whom the rank and file have handed over the entirety of their interests. But amid all the turmoils and exasperations of the present deplorable and utterly wasteful system of strike and lockout, there are recurrent and increasing signs that saner councils and sounder leaders are gradually gaining. And it is in this direction that the hope of the future lies. Far-sighted manufacturers might well think carefully over the words addressed by President Mellen to his employees on the N. Y., N. H. & H. RR. a few weeks ago:—

"I am going to surprise you by saying that I regard the unions as a condition that has come to stay; that I have no prejudice whatever to properly-conducted ones, and express my wish that our men generally would join them, not that I would run a union plant as such, for I would not coerce my men nor consent to discriminations as between those who were and who were not members, but I would wish to have in the unions the conservative influence of many of the good men who are out, to counteract the floater, the anarchist, the man who has nothing at stake in the world, who works with his mouth more than his hands.

"My advice to you who have families, who have a stake in the world, is to join your unions, and make yourselves felt in them. Be always a force for conservatism. It seems to me as much in your interest to do this as that you shall attend the caucus and nominate good men for office and vote for them at the polls. Your apathy is the opportunity of the demagogue, the anarchist, the floater, who has nothing to lose."

The gist of the proposition is that unionism must be recognized as a permanently established institution. It has undoubtedly been necessary in the past, and sometimes is necessary still, to check its intolerance and its violence with a stern purpose and a strong hand. But the most effective treatment, the most rapid amelioration, will come from the internal influence of better men inside the unions.

* * *

THE most sensational development of late relating to the status of unionism is the much discussed decision of Judge Adams of the Illinois Appellate Court. In the case in question the unions attempted to enforce, by strike, certain most outrageous demands, and among them one for the exclusive employment of union men—in other words, the closed shop. They picketed the works, were enjoined, persisted, and were fined and the ringleaders jailed for contempt. The case came before Judge Adams on appeal. He holds that a strike to compel an agreement constitutes duress, is unlawful, and renders any agreement or contract obtained voidable; further—a much more important point—that the proposed agreement in this case would itself be unlawful because it would:—

"if executed, tend to create a monopoly in favor of the members of the different unions, to the exclusion of workmen not members of such unions. * * * Contracts tending to create a monopoly are void."

The decision, naturally, has been sharply criticized, but it is said that counsel expect it to be sustained in the Illinois Supreme Court. If so, it will be one of the most important leading cases in the United States.

* * *

WITH the conclusion of the competition for the design of the United Engineering Building, to be constructed in New York for the use of the three National engineering societies which have accepted the generous offer of Mr. Andrew Carnegie, the work upon this important undertaking may be fairly said to be commenced. As has been announced in the daily and technical press, the successful contestant in the architectural competition is Mr. Herbert D. Hale, whose designs, subjected, with the others, to a most exacting scrutiny by the conference committee and their consulting architect, Professor W. R. Ware, were found to be most suitable for the conditions of the undertaking.

It is understood that four points were taken into account in making the decision, these covering the most important elements of the proposed structure: the façade, the main auditorium, the library, and the executive quarters for the several societies. Each design was considered as to each of these features, and by a process of gradual elimination the various plans were passed upon until the most satisfactory combination of all was found in the plans submitted by Mr. Hale. During this study the various designs were known only by numbers, the members of the committee being entirely in ignorance of the identity of the successful competitor.

Mr. Hale is to be congratulated upon the successful manner in which he has passed this severe ordeal, and there is no doubt that the completed structure will bear witness to the wise judgment of the committee and of Professor Ware.

In accordance with the suggestion of the joint library committee, the plans provide for the location of the general library and reading room upon the uppermost floor of the building, with such arrangement of top lighting as will make this portion a convenient and practical work room for the users of the valuable collection of books there to be assembled. The floor beneath is also to be devoted to the use of the library, so that ample space will be provided for this most important department in the work of the joint occupants of the building.

Scientific libraries are too often found to consist of valuable collections of books so guarded and hedged about with restrictions as to impair to a great extent their usefulness, but it is believed that in the new building on Thirty-ninth Street there will be found an engineering library which will be used as well as cared for, and which will become the standard centre from which information upon all branches of engineering will be disseminated over the whole country; while the resident or visiting engineer will find not only a courteous welcome, but also intelligent and cordial assistance in the conduct of his researches.

It is expected that work will speedily be begun upon the new building, and that its completion will not be long delayed.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

INTERURBAN ELECTRIC RAILWAYS.

THE ADVANTAGES OF INTERURBAN ELECTRIC TRANSPORT AND THE CHANGES WHICH IT HAS WROUGHT IN THE TRAVERSED COUNTRY.

G. M. Walker—Street Railway Review.

ALTHOUGH the earliest ideas of electric transport were developed in connection with the substitution of mechanical for animal power in street railways, the extension of the electric railway to communication between neighboring towns has been a legitimate and important feature of its progress. The conditions which led to the successful development of interurban railways, and the precautions which should be taken with similar enterprises at the present time are very thoughtfully discussed in an article by Mr. G. M. Walker in a recent issue of the *Street Railway Review,* from which we make some abstracts.

"It should hardly be necessary at this late day to make any extended argument to prove the advantages and necessities of interurban railways. The convenience of their frequent service and its extreme cheapness have wrought such a change in farm life that wherever these interurban roads have been built there can hardly be said to be any country at all but that the whole region has become transformed into a great though scattering city.

"The farmer along the line of one of these roads enjoys at the cost of 15 or 20 minutes in time and a few cents in fare almost every convenience of the dweller in the city. He can go to town for business or pleasure at any hour of the day. His crates of fruit, barrels of vegetables and cans of milk are picked up at his door and landed in the city market within an hour or two of the time that they are taken, fresh. It is easy for his wife to go to town after her morning work is done and like the city housewife return from her marketing and shopping in time to get dinner, and it is no more inconvenient for the farmer and his family to attend the theatre or the opera than it is to any other dweller in the city's suburbs.

"In addition to this they place it within the power of the farmer to take advantage of every fluctuation in the price of his farm products and to place those products on the market without delay in time to dispose of them to the best advantage. To the city dwellers these interurban roads make possible the dream of years and they flee from the crowded cities to settle on two, three, or five-acre tracts along the line of these roads, there to enjoy in the midst of their gardens the pure air, the quiet and the healthful conditions of country life.

"In thickly populated communities these interurban roads have proved profitable investments to those who have built them while they have increased enormously the value of and demand for the lands through which they have run. As a rule all lands desirably located and within reaching distance of these interurban lines have doubled in value and increases from $50 to $100 per acre in the selling price of farms along these lines is common even where the distance from the city is so great as twenty miles."

These considerations have led to the construction of numerous interurban railways, and when the locations have been well selected the lines have been profitable

to the original investors and also highly beneficial to the communities and districts through which they run. The best locations having been taken up, however, the question arises: How shall such railways be developed in sections which are too sparsely populated to attract capital? It is this question which Mr. Walker discusses at length, and while all may not agree entirely with his views, the points which he makes are those which must come up for settlement in actual practice.

There is no doubt that the residents of the communities along the line of a railway will be benefited by the opening up of their land, and farms which, with imperfect transportation facilities could be operated successfully only with staple crops in large bulk become available for division into small tracts for intensive farming as soon as cheap and rapid transport is provided. At the same time the capitalist cannot be expected to put money into the construction of a line through a district where the population is evidently insufficient to give a paying business from the start. In other words, each party is dependent on the other, and neither feels prepared to take the initiative.

Mr. Walker takes the position that the initiative lies with the residents of the district through which the railway passes.

"A community must pay the cost of its own development, and if it has reached the position where an interurban car service is necessary for its further development it must pay the cost of such a service. If this service is such as to require one thousand users at the ordinary rate of fare to make it pay, and the community has at present only five hundred such users there is no possible way by which the company furnishing such service can do so at ordinary rates except at a loss. The consequence is that if the community of five hundred users are to have this service they must pay for it the sum equal to the normal charge from one thousand users. This would necessitate a charge equal to double the normal rate which by making the fares high and the freight rates excessive would defeat the very purpose which they have in view, namely, to induce emigration into their community by furnishing it with transportation facilities at low cost."

As a comparison from an analogous situation Mr. Walker refers to the history of the development of steam railroads in the United States, showing that in localities west of the Allegheny Mountains private rights of way were offered to the railroads, and cities and towns vied with each other in their efforts to secure the construction of railroads to or through them. In the case of the State of Ohio, it appears that in the fifty years from 1850 to 1900 the miles of railroad increased from 575 to 8,768, while the population practically doubled from 2,000,000 to 4,000,000, and the wealth increased about eleven times, or from $500,000,000 to $5,800,000,000. Mr. Walker argues from these figures that the great proportional increase in wealth per capita was due to the development of the railroads, and while this may partially be the case it is more probable that the increases both in railroads and wealth were the results of the general development of the country, being themselves the results of a number of active and powerful causes, all tending in the same general direction. However this may be, there is no doubt that the prosperity of railways, whether steam or electric, is closely bound up with that of the country through which they pass, and that both should have common interests if the best advantages are to be realized.

"While the character of the traffic of these two classes of roads is different, the relative conditions of developing them are the same and the process which secured for the country its splendid systems of steam railroads must be pursued to secure the construction of the interurban electric railways that are now necessary to supplement the service of the steam roads and insure the continued growth of our country in produce and wealth.

"The idea seems to be widespread that electric lines are cheaper to build than steam railroads, but nothing could be farther from the truth. The right of way grading, ties and rails cost just as much for one as for the other, but at this point of the investment a steam railroad is ready to operate, while the electric line must invest a sum half again greater than the cost of all this to erect a pole line with overhead trolley and feed wires, while its power houses are

far more expensive than locomotives and every electric car equipped with high power motors costs as much as an ordinary locomotive. This greater original cost of an electric line over the cost of a steam railroad is one of the things that makes it particularly necessary for the communities desiring them to contribute to the cost of their construction.

"In those localities where population and traffic are already sufficient to support these interurban railways they have been built. But those other localities without the necessary population and traffic must, in order to secure the construction of these interurban railways which are so necessary to their further development and prosperity, do as the government did in the case of the steam railroads; offer inducements to private capital to secure their construction, and these inducements or subsidies must be sufficient to reduce the cost of the road to the investors furnishing the funds to pay for its construction to a figure which the expected traffic will carry or to insure the operation of the road without loss until such time as it can build up a population and traffic sufficient to support it."

Although Mr. Walker assumes that the inducements to establish an interurban railway should come from the inhabitants of the communities through which it passes, he overlooks the fact that in many instances the capitalists who undertake the construction and operation of the road are themselves interested in the development of their own holdings along the line, and that it is not altogether an unknown plan for the investors in a railway to first become possessed of choice portions of land along the proposed line before the possibility of its construction has been made public. In some cases the projectors of a line expect to derive the greater part of their own profits from the increased value of their own land holdings along the line, leaving the other stockholders to wait for their returns until such time as the returns from operation warrants dividends. Such methods surely cannot be unknown to one so familiar with the other workings of railway development as Mr. Walker has shown himself to be. The real truth of the matter is that the best interests of the country are served in railroads as in other industrial developments, when those who use them are also those who profit by their use, and hence are most interested in their honest and capable exploitation and successful commercial development.

THE UTILISATION OF PEAT.

APPLICATIONS OF IMPROVED METHODS OF PREPARING AND COKING PEAT AND OF RECLAIMING BY-PRODUCTS.

Dr. L. C. Wolff—Verein Deutscher Ingenieure.

PEAT is a substance composed almost entirely of the decomposed remains of vegetation, principally certain mosses and allied plants, and it has been used for centuries as a form of inferior fuel. Within recent times, however, it has assumed an increasing importance, largely because of improved methods of preparing and using it, and hence a discussion of its properties and technical applications is a matter of interest. In a paper by Dr. L. C. Wolff, in a recent issue of the *Zeitschrift des Vereines Deutscher Ingenieure*, a study is made of the calorific power of peat fuel, together with some account of the modern methods of preparation, from which we make some abstracts.

Although peat is composed almost entirely of organic matter, it contains also nearly 90 per cent. of water, so that any attempts to use it in its natural condition give very meagre results, nearly all the heat evolved by the combustion being absorbed by the evaporation of the water. When the peat is dried in the air it retains only about 20 per cent. of water, and it is in this condition that it is generally used as domestic fuel by the peasants of Ireland and the Continent.

The later and more scientific methods of utilising this natural fuel involve a further degree of preparation than the mere drying of the mass. As originated by Ziegler, the modern method involves the coking of the dried peat, this furnishing a clean fuel standing about midway between charcoal

and ordinary coke, and being free from sulphur and so especially suitable for certain metallurgical operations. The volatile matter is distilled off as gas, this furnishing more than enough heat by its subsequent combustion to effect the coking, while the condensible tarry residues contain valuable by-products. According to Dr. Wolff the products of the operation of coking are: coke, 27 per cent., tar, 4.5 per cent., tar water, 31 per cent., and fuel gas, 37 per cent. From the tar there may be extracted various oils, paraffin, etc., while the tar water contains wood alcohol, ammonia, and acetic acid, these latter being readily converted into sulphate of ammonia and acetate of lime, and thus rendered marketable products. Since the production of gas is in excess of that required for heating the ovens it may also be used for firing steam boilers, or the excess may be utilized directly in gas engines for the production of power. The calorific value of the gas is fairly high, since it contains about 15 per cent. of methane and 24 per cent. of hydrogen, determinations giving 2,877 calories per cubic metre, or about 323 B. T. U. per cubic foot.

Dr. Wolff gives some figures for the commercial side of the operation, from which he shows that 10 metric tons of coke, costing 50 marks, will produce coke and by-products worth 584 marks, which certainly should leave a margin for profit even after the operative expenses have been deducted.

Peat coke appears in many ways to be an ideal fuel. It has a calorific value of 7,889 calories per kilogramme, or 14,200 B. T. U. per pound, holds well together in the furnace, and produces a very small proportion of fine ash. It contains no sulphur, and hence is without injurious action upon boiler plates or heating kettles, and produces neither smoke nor smell. As a combustible it has all the advantages of wood charcoal, together with absence of friability, either in handling or in the fire, rendering it especially applicable for metallurgical operations.

Owing to the great extent of the peat bogs and moors in Germany and northern Europe generally, the development of commercial processes for its complete utilisation means much to the nations concerned. From a subordinate position, as the domestic fuel of a limited number of peasants, dwelling near the moors, it may become an important source of personal and national wealth, not only from its applications but also because of the employment which its exploitation will naturally give to residents of the land. The removal of the peat, so far from injuring the land, will make it better adapted to cultivation, and the entire operation offers such advantages as assuredly render it a matter for close investigation and technical as well as commercial study.

POWER STATION DESIGN.

GENERAL ARRANGEMENT, EQUIPMENT, AND SYSTEM OF OPERATION OF GENERATING STATIONS FOR ELECTRIC-POWER SUPPLY.

C. H. Merz and W. McLellan—Institution of Electrical Engineers.

A COMPARISON of a modern well-designed electric generating station with one representing good practice of a comparatively few years back must impress even the non-technical observer with the development which has been made in this important department of engineering work. The advances which have been made in electrical engineering are undoubtedly rapid, but a generating station really represents steam engineering, building arrangement and construction, mechanical transport appliances, and a vast multiplicity of mechanical details, together with the electrical portion of the equipment, and it is in the whole combination of a number of elements that progress has been made by application of the experience gained in practice. In a paper recently presented before the Institution of Electrical Engineers by Messrs C. H. Merz and Wm. McLellan, some of the salient features of modern power station design are discussed, and the paper, together with the animated discussion which it elicited, is of much interest and value.

The variety of electric generating stations renders it necessary for a single paper to

be limited to some definite class, and the authors state at the outset that they propose to consider, in general, the requirements of a station of 5,000 kilowatts or over, of a general power-supply undertaking (power, traction and lighting) of a district extending over a considerable area. In the case of such a station economy must be considered, since the commercial success of the whole enterprise depends upon its ability to meet the conditions of price necessary to obtain customers.

A general power supply system should be considered as made up of two parts: the generating station and the distribution. These must be considered together, since the nature of the distribution selected controls very largely the character of the generating plant, but at the same time the two portions differ materially in their influence upon the economy.

The power station has hitherto occupied the greater share of attention of the designers of a system, but this is not warranted, since the distribution costs fully 50 per cent. of the total outlay, and it must in general be planned and put down with a greater margin for future extensions than is necessary with the station itself, since this latter may generally be begun on a moderate scale and extended as the demand requires. By allowing a sinking fund of 10 per cent. per annum to provide for future changes a fair provision may be made in this respect.

The main principles laid down for guidance in power station design are: simplicity of design; subdivision of plant and apparatus; arrangement of labor-saving devices, and provision for future extensions.

In considering the type of power generating plant to be used, the authors of the paper dismiss the reciprocating steam engine with scant mention, assuming as settled the fact that the only competitors worthy of consideration for the modern power house are the steam turbine and the gas engine.

"Steam turbines seem in every respect to be specially suitable for power scheme purposes, and although they have taken many years to develop, it is probable that had there been a demand ten years ago for 2,000 k.-w. generating sets, turbo-alternators would have been the only large-size generating units in extensive use at the present day. Their earlier commercial success was prevented by the fact that there was only a demand for small sizes (300 k.-w. and under), at which sizes any superiority which the turbine even at the present time possesses over reciprocating engines is due to saving of labour and oil rather than to either lower cost or reduced steam consumption. In large units the adoption of turbines materially reduces the capital cost of a power station. This reduction amounts to from 15 per cent. to 20 per cent. over the whole station even on present market prices, and it will be much greater when the manufacture of turbines has become as completely standardised as that of reciprocating engines. If the reduction be calculated on the engine and dynamo alone, the percentage is naturally very much greater. The mere fact that this saving is not available in small sizes greatly assists a power company in its competition with private plants, as a private user, utilising, as he must, relatively small units, does not reap anything like the same advantage as a power company from the adoption of turbines either in first cost or in steam consumption. We are here discussing a station for power supply which involves alternating units, as large continuous current turbo-generators, due to the troubles of commutation at high speed, have still a somewhat limited field.

"The high thermal efficiency of gas engines has long rendered their use attractive to power station engineers, more especially in the south of England, where coal is expensive, but, although we may eventually look forward to the time when a gas motor fulfilling the requirements of a power station will be obtainable, it can hardly be denied that, for this purpose, the gas engine has not at present attained the same perfection as the steam turbine.

"Apart altogether from the importance of utilising more efficiently the heat energy in coal, there are large possibilities in utilising gas which is a waste product, or which is obtainable in conjunction with some manufacturing process. These possibilities make it particularly desirable to utilise gas direct in the prime mover without the agency of steam. This paper, however, refers essentially to the design of power sta-

tions where coal is the fuel, either in a boiler or in a gas retort. The conclusions drawn under this section must in no sense be taken as implying that in the opinion of the authors gas engines are impracticable for power stations where waste gas from blast furnaces or other source is available."

The general arrangement of the plant includes the location of the generating station, which should be well within the area to be supplied, unless questions involving the supply of materials, water, gas, etc., become of controlling influence and favor a location at the extreme boundary. The structure itself should be treated merely as a shell to contain the generating plant effectively, but as cheaply as possible. A steel-framed structure, with brick, concrete, or corrugated iron sheathing is probably the most satisfactory.

In considering the general lay-out of the buildings the modern station is tending toward what may be called the complete unit system. This does not necessarily mean that each unit consists of but one generating set, but that the plant is divided into separate sections, each section consisting of the steam, power, and electric machinery of a certain portion of the whole, so that any interruption of one unit would have no effect upon the others. This does away with the steam main into which all the boilers feed and from which all the engines draw their supply of steam, as in the older plants, and makes the power plant an aggregation of independent units. The buildings should consist of three components: the boiler house, or gas-generator house; the engine room, which is also the room for the electric generators, and auxiliaries; and the switch galleries, or separate switch house. By arranging these components along three parallel lines they may be extended in a systematic manner, as may be required. Illustrations of several executed designs showing this plan are given in the paper, and especial stress is laid upon the manner in which the steam turbine is adapted to such service. The system of separate units also makes the provision of spare plant a part of the whole, since the installation of one or more units in addition to the immediate requirements furnishes the reserve equipment along the line of further extension. The size and number of units must in all cases be determined by the operative requirements of the service. Single generating sets of 1,500 to 2,500 kilowatts output, with a capacity for 50 per cent. overload, have been used with success, generating three-phase current of 40 or 50 cycles, at any convenient voltage, transforming as may be required by the service.

Although no precise figures as to installation costs are given in the paper, it developed in the discussion that the entire cost of such a station as is outlined is considerably below £20 per kilowatt.

INTERNAL COMBUSTION MOTORS.

IMPROVEMENTS AND DEVELOPMENTS IN GAS, OIL, AND PETROLEUM ENGINES DURING THE PAST TWENTY YEARS.

Dugald Clerk—Institution of Civil Engineers.

IN engineering, as in other fields of work, the lines along which progress may best be made are often indicated by a study of the past, and in this respect, as well as for its general importance, the James Forrest lecture of Mr. Dugald Clerk, delivered before the Institution of Civil Engineers, demands attention and comment. Mr. Clerk is pre-eminently fitted to discuss the subject of internal-combustion motors, he having been one of the ablest pioneers in this important line of work, and himself being the inventor of many improvements in such machines. Both as an engineer and as an author he has shown himself to be an able specialist in this field, and there is to-day no one better qualified to speak with authority upon the subject.

Referring to the work of the past twenty-five years, Mr. Clerk says:

"Development has followed two main lines. First, improvements relating to the motor itself, including changes in the thermodynamic cycle, followed in the treatment of the working fluid and the inflammable gas within the motor by the modification of such details as admission valves, igniting

devices, governing devices, and water and air-cooling devices. Starting gear has also been carefully studied, and, both from the thermo-dynamic and the mechanical point of view, it may be safely said that these motors have attained a great measure of perfection. Secondly, parallel with the improvements relating to the motor itself have proceeded those relating to means of generating the inflammable, gaseous, or vapor fuel intended to operate the motor. These improvements have related to the economical production of ordinary coal gas, to the effective production of producer gas from anthracite, bituminous non-caking coal, coke, and other solid fuels, to the treatment of heavy and light hydro-carbons and alcohol to produce an effective inflammable vapor, and to the purification and collection of blast furnace gas, coke oven gas, and natural gas."

In examining the performance of internal-combustion engines the heat which is supplied by the fuel reappears in three portions. One part is converted into mechanical energy, and is available for application to useful purposes. Another portion is carried off without change by the water which circulates in the cylinder jacket, while the third goes out the exhaust pipe with the discharge of the contents of the cylinder. The water-jacket for the cylinder is a mechanical necessity, since without it the working parts would become so overheated as to interfere with their operation, while the discharge of the heat in the waste gases is an obvious necessity, to be minimized if possible, but not to be entirely prevented. Mr. Clerk tabulates various gas engine tests from 1882 to 1900, giving the heat balances, these showing the extent to which the relation between these various quantities of heat has been changed by improvements in the engines built during that period.

Thus, in 1882 tests made by Slaby showed only 16 per cent. of the heat was converted into useful work, while 51 per cent. was carried off in the cooling water. Gradually the proportion of heat utilised has been increased until about 30 per cent. has been attained, while there has been a continual decrease in the amount of heat carried off by the jacket. At the same time the proportion passing out with the exhaust gases has increased, so that there has been what may be called a redistribution of the heat.

"To understand the reasons for this it is necessary to consider briefly the thermo-dynamics of this subject so far as it is at present understood, in order to see whether further knowledge is required to enable the meaning of the relative losses and gains in these engines to be better appreciated. Although the general thermo-dynamics of the internal-combustion motor may be considered to be broadly understood, yet physical and chemical knowledge of the properties of air and other gases at high temperatures is as yet insufficient to enable the physicist or engineer to formulate a quantitatively accurate standard engine of comparison; that is, to formulate a conceivable engine in which all heat losses by conduction and radiation are suppressed, and where the efficiency is the full efficiency of the particular cycle under the assumed conditions, whether perfect or imperfect.

"The present position of the theory of the internal-combustion motor is in the state of that of the steam engine at the time of Watt, before the accurate determination of the properties of steam. As Watt knew of the latent heat of steam, but did not know all its properties accurately through a considerable range of pressures and temperatures, so engineers now know of a similar absorption or suppression of heat existing in gaseous explosions without knowing accurately its causes or proportions under all the various conditions of practice. It is perhaps in this task of settling the data for an accurate standard engine of comparison that the physicist and chemist can assist the engineer most effectively. So far, by following the broad lines indicated, heat efficiencies have improved from 15 per cent. to 30 per cent.; and, without doubt, further improvement in efficiency will be made, but with present knowledge it would be impossible to say that the next twenty years would carry us from the 30 per cent. efficiency of to-day to, say, a 60 per cent. efficiency. That efficiencies can be increased much further cannot be doubted. This is evident from an examination of the change in efficiency which may be produced under certain conditions in an engine operated by pure air.

Such a standard was first proposed by me in a paper read before the Institution in 1882. In that paper it was recognized for the first time that a standard most nearly approximating to practical conditions of that day would give constant efficiency for a given compression volume for all maximum temperatures above the temperature of compression. The standard engine of comparison, which would correspond most closely with to-day's practice, is an air-engine operated between a maximum and minimum volume as follows:

"Adiabatic compression of air from maximum to minimum volume; addition of heat at minimum volume, raising the temperature from the temperature of compression to the maximum temperature; adiabatic expansion to maximum volume, and discharge of heat at maximum volume."

If it is assumed that the specific heat of air is constant throughout the entire temperature range, the efficiency will be constant for all maximum temperatures; that is, for all heat additions above the temperature of adiabatic compression. Taking air as the standard, Mr. Clerk computes the maximum efficiencies possible for various degrees of compression, showing that for a compression of one-half the efficiency will be 0.24, while for 1.100 the efficiency may become as great as 0.85. In present practice compression has been carried as high as 1.7 to 1.10, and the corresponding efficiencies are 0.55 and 0.61. It is not to be expected that these theoretical efficiencies can be realized in practice, since constructive and mechanical difficulties are in the way. A comparison of recent tests, however, show that from 0.5 to 0.6 of the standard efficiency of the air engine, operating at the same compression, may be attained with existing designs. In order to obtain the best efficiency the cylinder should be cooled as little as possible, and the compression should be carried to the highest practicable point. Although Mr. Clerk does not mention the fact these points are the very ones which have been followed by Herr Rudolph Diesel in the design of his motor. Diesel has gone so far as to advocate the entire abandonment of the water jacket, although this has not been found desirable in practice, while he carries the compression to a higher point than has been attempted by any other designer. The real difficulty about high compression with the ordinary mixed charges is the danger of pre-ignition from the heat of compression, as Mr. Clerk very clearly points out. Since Diesel compresses only the pure air, and does not inject the fuel until the end of the compression stroke, he experiences no trouble on this score, while at the same time the heat of compression insures an immediate ignition, and avoids the necessity for any independent method of ignition. For other forms of internal-combustion engines, however, the limitations of compression by fear of pre-ignition constitute a distinct barrier, especially with large engines. Any attempt to prevent this trouble by excessive cooling reduces the efficiency by reason of the greater portion of heat carried off by the jacket water.

"The internal combustion motor offers, perhaps, the best instance of international industry which could be imagined. England stands at the head of all nations in the production of the smaller and medium-sized fixed gas engines. She has produced altogether something approaching 100,000 engines of an average of 20 horse-power This is greatly in excess of the whole Continental output of engines of this type taken together. On the other hand, Continental engineers have given more attention to the large gas engine—engines of 500 horse-power and above—and the application of blast-furnace gas to the use of the large engine. In this field of internal combustion motor work Germany excels.

"In the petrol motors for motor carriages France appears to take the lead, and in heavy oil engines England takes the lead. In America engineers are now giving considerable attention to the internal combustion motor; but so far, for some reason, the Americans have not shown in this subject the inventive and progressive spirit which they usually display. They have, however, taken considerable part in the application of petrol motors to small vessels and boats.

"It may be said, however, without exaggeration, that the whole world is now alive to the possibilities of the internal combustion motor, and that progress will be more and more rapid. These motors have almost fulfilled the expectations of those engineers

who—like myself—have devoted a large part of their lives to their study and advancement. They are looking forward now to the completion of the work begun so many years ago, and expect, at no distant date, to find the internal combustion motor competing with the steam engine, even in its latest form, the steam turbine, on sea as vigorously as it does at present on land."

It will be interesting to compare the views thus expressed out of the ripe experience of Mr. Clerk about the relation of the gas motor to the steam engine with those of the authors of the paper mentioned in the preceding review. The gas engine has certainly made rapid progress of late, and it will hardly do to dismiss it with brief mention, as if it were a mere toy.

THE REVERSIBILITY OF THE HYDRAULIC TURBINE.

A SCIENTIFIC STUDY OF THE RELATION OF THE HYDRAULIC WATER WHEEL TO THE CENTRIFUGAL PUMP.

Platon Yankowsky—Revue de Mécanique.

WE have heard much of late about reversible and non-reversible cycles in heat engines, although there is apparently room for further discussion in that direction. We now have an important and interesting paper, by M. Platon Yankowsky, of St. Petersburg, published in a recent issue of the *Revue de Mécanique*, examining the theory of what M. Rateau has called "turbo-machines," and showing the extent to which such machines are reversible. Professor Yankowsky confines himself to hydraulic machines, and takes up the equations of Herrmann and elaborates the theory in a most interesting manner. For the mathematical development the reader must be referred to the original paper, but the general consideration of the subject may be examined here as having interest to the engineer for various reasons.

If we have a flow of water from a higher to a lower level there is developed mechanical energy theoretically equal to that necessary to raise the same volume of water to the same height in the same time. If we place in the path of the descending water a piston hydraulic engine it will be driven, while a piston pump, placed in the pipe may be used to elevate water if driven by some external source of power. The use of a turbine to take the power from the falling stream, or a centrifugal pump to raise the water in the second instance, does not change the general nature of the problem, if the efficiency of the machines remains the same. If, however, the efficiency be considered as a variable element the matter demands further study. The piston hydraulic motor may be considered, theoretically, as having an efficiency of unity, and the same may be said of the piston pump; friction and leakage being, for the moment, neglected. When we take the efficiency into account, however, the limitations or reversibility become apparent.

Taking the original equations of Weisbach as modified by Herrmann, and using the constants of Zeuner, Professor Yankowsky shows that the difference between the fundamental formulas for a turbine and a centrifugal pump consists only in the change of sign for certain terms. It is evident, however, that no matter how low the efficiency of a turbine, it will continue to act and to deliver its corresponding proportion of mechanical energy upon the snaft. When a turbine of low efficiency is used as a pump, however, the energy which does not appear in useful work is absorbed in the internal resistances, and hence it is necessary that the efficiency shall be greater than the internal resistance if any pumping action is to be obtained. This agrees fully with the mathematical deduction from the equations, which show that a condition of reversibility is that the machine, considered as a motor, must have an efficiency of more than 50 per cent. There is an analogy in this respect with other mechanical devices. Thus the differential chain block hoist, as is well known, will hold its load suspended, without "overhauling" or running back, and this property has been shown to be dependent upon the fact that it possesses an efficiency of less than 50 per cent. In the case of the more modern hoisting machines, having efficiencies of more than 50 per cent.,

it is necessary to provide some form of brake, usually thrown out of action automatically during the operation of hoisting, otherwise the load will not be sustained when the hoisting power is removed.

Another way of putting the question is found in a formula similar to the well-known proposition of Carnot relative to the efficiency of heat engines. Thus, if T be the useful work of the machine, considered as a pump, and t be the work lost in overcoming internal resistances, the maximum effect of the machine will be given by the expression:

$$\frac{T - t}{T}$$

Now when the efficiency of the machine is 50 per cent. the useful work and the opposing resistance are equal to each other, and the numerator of the above fraction becomes zero, and hence its value will also be zero and the device becomes inoperative.

Professor Yankowsky shows that the division of turbines into the two classes of reaction and impulse wheels bears an important relation to the question of reversibility. The reaction turbine, acting by the pressure of the water, is a reversible machine, while the impulse wheel is irreversible. Thus a wheel of the Fourneyron type may, without change, be converted into a pump, and this experiment has been successfully tried by Professor Yankowsky in his laboratory at the Institute of Ways and Communications at St. Petersburg, although the turbine was one of an old type, built in 1860, and without any such reversed action in view. It is evident, however, that an impulse turbine, such as the Pelton wheel, is irreversible, and that driving it backward by an external application of power would produce no pumping effect.

The important object which may be attained by the study of the reversibility of turbines lies, not so much in the fact that the thing can be done, as that it forms a basis for a scientific investigation of such machines, with a view to their increased efficiency. Since the perfectly reversible machine must be one having an efficiency of unity, any improvements in design directed to the attainment of the best action both as a turbine and as a pump must conduce towards the maximum efficiency, and when the perfect reaction turbine is produced it should also be the perfect rotary pump.

An interesting analogy to this hydraulic problem is seen in the corresponding question in electric generation and application. The fact that the dynamo is a reversible machine is the reason for the existence of the electric motor in its analogous form, and the completeness of the reversibility accords fully with the high degree of efficiency of both machines.

The extensive use of the principle of reversibility for testing the accuracy of many scientific instruments is well known, and it will be an interesting parallel if it appears that the test of reversibility of action is established as a general principle in machine design.

PROGRESS ON THE JUNGFRAU RAILWAY.

THE CONSTRUCTION AND OPERATION OF THE FIRST PORTION OF THE ELECTRIC RAILWAY FROM INTERLAKEN UP THE JUNGFRAU.

L. J. Sidler—Génie Civil.

JUST six years ago there was reviewed in these columns an account of the proposed electric railway to the summit of the Jungfrau, in Switzerland, and at that time it was hoped that the completion of the work would not occupy more than five or six years.

We now have an account of the railway and its operation, not indeed to the summit, but to the station Eismeer, or sea of ice, situated at an altitude of 3,161 metres (10,371 feet) above sea level, the altitude of the summit of the Jungfrau being 4,166 metres, or 13,668 feet above sea. This portion, representing 5.66 kilometres of the total of 12.5 kilometres distance between Little Scheidegg and the summit, is now in regular service, there being six electric locomotives in use, deriving their power from the hydro-electric station at Lauterbrunnen on the White Lütschine; the second station at Burglauenen, on the Black Lütschine, not yet being completed.

The constructive difficulties of this por-

tion of the road represent by far the most important of the work, and there is every reason to believe that the remainder will be completed without any serious delay. The Little Scheidegg, the starting point of the electric railway up the mountain, is the terminus of the steam railway between Lauterbrunnen and Grindelwald, connecting also with Interlaken, this latter being the point from which probably most of the tourist travel will originate. Although the summit is not yet attained, the portion of the road already completed affords some magnificent views of the alps of the Bernese Oberland, and from a description of the railway recently published by M. L. J. Sidler in *Le Génie Civil* we abstract some account of the work and its operation.

After passing the station Eigergletscher, from which a fine view of the numerous peaks of the Bernese Oberland is obtained, the road passes into a tunnel about 10 kilometres in length, in which there are three stations, these being situated in chambers cut out of the solid rock, and provided with rooms for the buffet and for the attendants, and having openings like windows through the mountain side from which the landscape without may be seen. From the Eismeer station, at the outlet of the tunnel, the railway will proceed at the moderate grade of 6 per cent., to a point immediately beneath the summit, from whence a vertical lift of 73 metres will be constructed to carry the passengers to the extreme summit. The maximum grade of the portion of the road already built is about 25 per cent., while the uncompleted portion, about one-half of the actual road length, is less difficult and will doubtless be executed without material delay.

To the engineer the most interesting portion of the work is that of the power development and the operation of the electric locomotives. This is especially the case because the installations represent the work of several establishments and of varying methods of construction. In the Lauterbrunnen power station there are two kinds of turbines, constructed on the Girard and the Francis systems, these operating under a head of 35 metres, and generating a total power of 2,650 horse power. The dynamos, generating a three-phase current at 7,000 volts, are by the Oerlikon Works, and by Brown, Boveri & Co., of Baden. Since the water supply for the turbines becomes insufficient during the winter, when the melting of the glaciers ceases, an auxiliary power plant, consisting of two gas engines, with a fuel gas producer, is also provided. At each station there is a transformer equipment, lowering the voltage from 7,000 to 500 volts, at which latter pressure the current is delivered to the motors on the locomotives.

The electric locomotives at present in use on the Jungfrau railway present several features of interest. There are six machines in operation on the portion already completed, three of these being built by Brown, Boveri & Co., and three by the Oerlikon Works. Mechanically the engines are identical, but there are material differences in the electrical details. The six locomotives may be divided into three classes, according to the method of control used during the descent of the train. In two of the locomotives the non-synchronous motors, being driven by the weight of the train, act as generators, delivering current to the main line. A third locomotive is similar in action, with the provision of a variable resistance which may be inserted to absorb to a greater or less degree the energy developed by the descent of the train. Experience with these locomotives showed that with the small number of trains in operation and the proportionately large amount of power developed during the descent, there were occasions in which the generating station was entirely relieved of load, the dynamos then acting as non-synchronous motors and causing serious difficulties in the operation of the plant. It was therefore thought desirable to arrange the locomotives so that during the descent they might be entirely independent of the power station, the energy developed by the descending train being entirely absorbed in the locomotive itself. It was with this idea in view that the fourth and fifth locomotives were constructed by the Oerlikon Works, and the sixth machine by Brown, Boveri & Co. In the first two machines the motors are also arranged to operate as generators, but the primary windings are not traversed by the three-phase current of the line, but are supplied with a continuous current generated by a small six-pole dy-

namo, mounted upon the shaft of one of the motors. The sixth engine is constructed on a different principle, the non-synchronous motors acting, during the descent, as continuous-current series dynamos.

The mechanical features of all the locomotives demand attention, especially in connection with the appliances intended to provide for the safety of the passengers. Each locomotive is provided with two electric motors, and each motor has a double train of gearing to the rack rail, so that the breakage of any part cannot interrupt the connection. The wheels gearing into the rack between the rails are mounted on separate axles from those of the supporting wheels running on the rails, so that the latter axles are free from any stresses due to the power transmission. The methods of arresting the descent of the locomotive are ample, in excess of any demands, there being three independent systems. The first of these is the system of electric resistance, by which the motors are operated as dynamos, under load, as already described, and this is intended to be the usual method of regulating the speed of descent. In addition to this there are two independent systems of mechanical brakes, the first consisting of two sets of brake shoes clamping by a screw movement against drums mounted upon the main motor gears, and the second being an automatic strap brake, acting directly upon a drum on the motor shaft, and thrown into action automatically whenever the the speed rises 25 per cent. above normal. These brakes act through the train of gearing upon the rack between the rails, but in addition to these there is an entirely separate safety clutch, which grips directly upon the smooth sides of the rack rail, so that it can be used in the event of any breakdown of any part of the duplicate system of gearing.

Although but one-half of the road is open to traffic the results have been very satisfactory, and during the past summer of 1903 nearly 30,000 passengers were carried to the Eigergletscher station. That the traffic will be greatly increased when the road is completed to the summit cannot be doubted, and the experience which has been gained in the construction and operation of this first portion will doubtless aid materially in the development and maintenance of the whole undertaking.

THE MEASUREMENT OF POWER.

DIRECT READING DYNAMOMETERS FOR THE DETERMINATION OF THE POWER DEVELOPED BY HIGH-SPEED MOTORS.

Col. Ch. Renard—Comptes Rendus.

IN determining the power developed by prime movers several methods have come to be accepted as standard. For the steam engine the indicator permits the mean effective pressure in the cylinder to be measured in a satisfactory manner, while with certain modifications, this instrument has also been used for the internal-combustion motor. With this last machine, however, the fact that the power developed by succeeding strokes may and does vary materially, so that readings form a number of consecutive strokes are necessary in order to enable a reliable determination to be made, and hence the continuous indicator has been devised for such purposes. At the same time it has become generally recognized that the most reliable method of measuring the power developed by an internal-combustion motor is that of the absorption of the entire power by some form of friction brake, the turning force and its moment giving the data necessary for the computation. For the steam turbine, the indicator is, of course, entirely inapplicable, and the power of such machines is generally determined, either by the brake, or by the measurement of the electrical energy developed in the dynamo which it drives, this, naturally, including the mechanical and electrical efficiency of the machines.

The advent of the small, high-speed internal-combustion motor, such as is used for automobiles, motor boats, and dirigible balloons, has created a demand for some form of apparatus which shall enable the power developed to be accurately and readily measured. The rotative speed of such machines renders the application of the ordinary form of indicator entirely imprac-

ticable. Certain special forms, with the piston replaced by a diaphragm, and the arm and pencil, by a mirror and beam of reflected light, have been employed, but such devices are adapted only for the mechanical laboratory, and have but a limited application. For these reasons the improved dynamometer, devised by Col. Ch. Renard, well known for his experimental work in practical aeronautics, and described in recent issues of *Comptes Rendus*, is of especial interest and importance.

The principle of the dynamometer devised by Col. Renard is so simple that it is a matter for surprise that it has not been employed for this purpose before. It consists merely in the utilization of the resistance offered by the air to the rotation of revolving arms upon which suitable vanes are mounted. As a regulator of velocity this device has long been employed in connection with such well known machines as the striking mechanism of clocks, or the driving gear of musical boxes, but its employment as a measuring apparatus of precision is another matter. Col. Renard, however, has subjected this simple device to a series of exhaustive tests, and has verified the fact that the power which it absorbs is practically dependent upon the area and form of the vanes, the density of the air in which it revolves, and the square of the speed of revolution. For a constant form of vane, therefore, and a constant density of air, the power absorbed by such a windmill is measured solely by the speed. Since the speed of rotation is limited only by the construction and strength of the materials, and the heat is carried off continually by the air, the device is especially adapted for the direct measurement of the power developed by high-speed automobile motors, and machines of similar character, to these it has been applied with great success.

In the machine illustrated and described by Col. Renard the dynamometer consists simply of a pair of arms, carrying square vanes of aluminum, this being placed directly upon the shaft of the motor. The motor is then allowed to run at the maximum speed which it can make against the air resistance thus opposed, and the power developed is computed from the speed. A little experience will enable the vanes to be so proportioned as to offer sufficient resistance to hold the motor to the desired working speed, and the dynamometer thus proportioned may then be calibrated to determine the power which it absorbs at various speeds.

The calibration of such a windmill dynamometer is readily effected by what Col. Renard calls a dynamometric balance, an ingenious modification of a principle already applied for another purpose. This balance consists of an electric motor suspended in such a manner that both the armature and the field are free to revolve. The frame, carrying the field, consists of a sort of scale beam, with pans in which weights can be placed. The windmill dynamometer to be calibrated is attached to the shaft of the motor and rotated, while the field is kept from revolving by placing weights in the scale pan. It is evident that the weight necessary to maintain the field stationary is a measure of the torque opposing the windmill, and thus the value of the constant for the dynamometer under test can be accurately determined. In this manner Col. Renard has constructed diagrams from which the power absorbed by his dynamometer for any given speed may be read at once, and it is only necessary to provide the machine with a reliable speed indicator to enable it to be used without any computations whatever.

Apart from the convenience of the apparatus for measuring the power of high speed motors, it having been used with satisfaction for machines up to 20 horse power, it has been used for investigations upon the resistance of the air to the motion of bodies of different shapes, and it may thus become a means of solving some of the problems in connection with aerial navigation. Its use has already demonstrated the correctness of the law that the resistance of the air varies as the square of the velocity, thus confirming the researches of Le Dantec, Canovetti and others.

The successful solution of the problem of the navigation of the air will probably be made by the development of apparatus which shall enable all the elements of the problem which are at present indeterminate to be accurately measured and investigated. For this reason the apparatus of Col. Renard demands attention and study, apart from its immediate practical uses.

SPACE DISTRIBUTION OF TIME.

THE PRECISE REGULATION OF TIMEPIECES OVER A LARGE AREA BY SPACE TELEGRAPHY.

G. Bigourdan—Comptes Rendus.

SEVERAL months ago we referred in these columns to the proposals of Mr. Nikola Tesla for the distribution of energy through space by means of magnetic waves, and noted his suggestion that any number of clocks might be operated in precise synchronism over a large area in this manner. It now appears that this has already been accomplished, and in a paper recently communicated to the French Academy by M. G. Bigourdan, and published in *Comptes Rendus,* the experiments are described.

The electrical distribution of time is by no means new, and both in Europe and America standard time is transmitted from the official observatories by means of master clocks fitted with electro-magnetic devices and connected by wires to receiving instruments in various cities. In the United States this method of synchronizing clocks is also used in large manufacturing establishments, in connection with mechanical time recording devices for workmen, this preventing any suspicion of irregularities or tampering with the mechanical timekeepers in the different departments.

The applicability of space telegraphy for this purpose extends its scope immensely, and since the object is attained simply by the transmission of uniform impulses it is really one of the simplest applications of the method which can well be imagined.

The experiments described by Mr. Bigourdan were conducted by him in connection with apparatus made for the purpose by Ducretet, the whole being very simple in design and action. A master clock was arranged to make and break an electrical contact every second. This operated a relay, which in turn discharged current into the primary circuit of an induction coil provided with an oscillator. The secondary circuit of the coil thus gave an oscillating discharge of very brief duration at regular intervals of one second. The two poles of the coil were connected, one with the earth and the other with an antenna of several metres in height, and by this means the electric waves acted upon a number of receivers, these latter beating regularly at intervals of one second in accordance with the action of the master clock. Two forms of receivers were employed, one being simply a radio-telephone of the Popoff-Ducretet system, in which the seconds beaten by the master clock were very clearly heard. The other form of receiver was similar to that of a space telegraph system, the Morse receiver being replaced by a recording chronograph with pen and travelling strip of paper. These operated in a very satisfactory manner, and with the paper moving at the rate of one centimetre per second the time could be recorded with a precision of 0.02 to 0.03 second.

Although the apparatus employed by M. Bigourdan in his experiments was very modest in its proportions it gave excellent results over distances of 2 kilometres, and would doubtless have served for greater distances had opportunity offered to install the receivers.

There appears to be no doubt that such a device as it was would answer perfectly for the electric distribution of accurate time over the entire area of Paris, and even to points beyond in the suburbs.

There are certain details to be observed in connection with the operation of the apparatus, such as the starting of the zero time at all points together, and the use of interruptions in practice at intervals of 10 or 12 seconds, in order to regulate the minute hand of the clock uniformly, but these are details which appertain only to the distribution of standard time for general use. For astronomical observations it would probably be better to send out the pulsations second by second by the observatory clock, and make the necessary instrumental corrections for the receiving chronographs afterwards in connection with the reduction of the observations.

The advantages of the space distribution of accurate time can hardly be overestimated, since the method obviates entirely the chief difficulty which has been found in the usual employment of electricity for this

purpose, that is, the necessity for running connecting wires to the point under consideration. The experiments of M. Bigourdan, it is true, covered but a small area, but the possibility of transmitting magnetic waves even across the Atlantic ocean has already been demonstrated, and it can readily be seen that a regular wireless time distributing service from Greenwich Observatory, for example, might be received by every vessel on the ocean lanes, merely by the installation of a receiver on each ship. Such a service would replace the chronometers, or rather supplement them to an extent which would render any deviation from the correct time impossible, and enable the longitude to be determined with a precision otherwise unattainable. In like manner the time might be transmitted over the entire width of a continent, such as Africa, and the explorer in the desert would be aided in determining his position with the additional use of but a few portable instruments.

It has been suggested that the exploitation of the remaining portions of the earth may finally be accomplished by methods of slow approach, establishing stations which shall each year approach nearer and nearer the goal, whether this be the North Pole, the Antarctic, or the interior of a continent, and one of the conditions of such a gradual conquest of the last terrestrial problems is admitted to be the necessity for the transmission of intelligence and energy. With the extension of the space distribution of energy, of which the above is but a trifling example, this portion of the equipment will be supplied, and the rest will not be slow to follow.

THE HEAT TREATMENT OF STEEL.

PRACTICAL EXPERIENCE IN THE PRODUCTION AND THERMAL TREATMENT OF STEEL IN LARGE MASSES.

Cosmo Johns—Iron and Steel Institute.

LABORATORY experiments and investigations are of the greatest value in metallurgical operations, but the difficulties of reproducing processes in the works upon a large scale frequently prevents the attainment of results which, in theory, are strictly correct, and which are readily produced on the small scale used by the scientific investigator. This side of the subject is often overlooked, and for this reason the paper of Mr. Cosmo Johns, presented at the recent meeting of the Iron and Steel Institute, is of much practical value.

"First, of all, the mass of the steel that happens to be under treatment plays a most important part, for heat takes an appreciable time in its transmission through the mass. Now, in a small laboratory specimen the mass plays a very insignificant part, the element of time is reduced almost to zero, and such terms as "rapidly heating," "cooling quickly in air," have a very definite meaning. It so happens, however, that the steel products in whose manufacture heat treatment plays a part are all of considerable size. For instance, a railway-axle weighing 500 pounds offers a mass that is out of all proportion to the small specimens often experimented upon, and yet axles are about the smallest of the steel products of the works whose methods the author is about to describe briefly.

"From an axle weighing 500 pounds to a marine shaft 26¾ inches external diameter and 86 feet in length is a stride that at once calls attention to the new conditions imposed. To ensure the homogeneity of a mass of steel like this is a problem of itself, having regard to the effect segregation of the elements plays in even moderate masses of steel; while to heat equally to a predetermined temperature, and then to cool it at a certain rate, are operations that tax the resources of the metallurgical engineer.

"Yet these, after all, are comparatively favorable examples. Certain steels are fairly easy to work and to treat in small masses, but when the mass is increased it becomes very difficult. Any attempt to heat or cool them rapidly would result in external or internal fractures. Take, for instance, a carbon steel, containing 0.60 per cent. carbon; in attempting to forge a

shaft, say, from a 40-ton ingot, the variation of temperature during the forging would induce stresses in the interior that in all probability would result in internal fractures with disastrous results when the shaft was used. Even with much lower carbon steels the same difficulties are met with, though to a less degree, and the mere heating or cooling of large masses of steel, 40 to 100 tons in weight, is a very delicate operation. Any attempt to accelerate the heating would cause the exterior to expand faster than the interior, and thus cause an internal fracture. A similar attempt to hasten the cooling would cause the exterior to cool faster than the interior—resulting in fracture again. But there are alloy steels even still more difficult to work. When large masses of these are treated they have to be kept in a heated condition until worked into their final form, and even then losses through fracture or 'clinks' are not uncommon.

"Then, again, time is a very important factor in thermal treatment. If a small laboratory specimen and a large forging be subjected to the same treatment, the resulting structure will be very different, even though the small specimen had been originally a part of the forging and was thus of the same composition.

"The explanation is clear. Suppose that both had to be heated to 1,650 degrees F. and dipped in oil, the cooling would be very rapid in the case of the small specimen, but in the case of the large forging the exterior would be quickly cooled, while the transmission of heat to the cooled exterior from the still heated interior would continue to take place for a considerable time. If the cooling were done in air the same difference would arise, and what was accomplished in minutes in one case would take days in the second. It is well, therefore, that this question of "mass" should be clearly recognised. One of the first lessons learnt in works practice is, that a course of heat treatment eminently suitable for a small specimen as determined in the works laboratory requires to be carefully revised, and the new factors of "mass" and "time" allowed for, before satisfactory, results are obtained with large masses.

"But 'mass' and 'time' are not the only elements that serve to differentiate works from laboratory practice. The manufacturer generally has to work to a specification, with rigid chemical and physical limits for his product. The author prefers not to enter into the vexed question of the expediency of these limits. The fact remains, that the specification has a very real existence and must be followed, but it also means that it limits the results that have to be aimed at and it is not always the ideal that is attained.

"To 'mass' and 'time,' therefore, must be added the 'specification,' and then we have the chief differences between the problem that presents itself in the works and the results of patient laboratory experiments."

As illustrating the practical application of the modern methods of steel working and heat treatment, Mr. Johns discusses the practice of the River Don Works at Sheffield, limiting himself to tires, axles, and shafts, and omitting discussion of armorplate and projectiles, or of steel castings.

An important element in the production of homogeneous steel is found in the arrangement of the ingot mould to prevent segregation and blow holes.

"The moulds are made of cast iron, with an upper portion of non-conducting material, designed so that the body of the ingot may solidify and be fed by the still liquid head. This head, being the last portion to solidify, serves to include the region of segregation, with the result that the top and bottom of the body of the ingots show very little variation in composition. If the entire mould were lined with non-conducting material many of the difficulties encountered in making large ingots in chilled moulds, would be removed, but there would be the objection that the ingot would solidify more equally over its mass, contraction cavities might be formed in the portion destined for use, while the region of segregation would probably occur there also.

"Needless to say, fluid compression is not used. It may seem late in the day to urge objections against the idea, but as in one or two quarters there remains a tendency to see some value in the process, it might be as well to state again the chief objections.

"Properly melted steel of the carbon used for products described in this paper contracts in volume when cooling, and, even after the exterior solidifies, the liquid in-

terior still keeps contracting, and on solidification forms internal cavities called pipes. If the ingot mould be properly designed this piping occurs in the head, leaving the body of the ingot quite solid. There will be no blow-holes in the body of an ingot made of properly-melted steel of the class we are describing. If there are any, that particular ingot is unfit for use in high-class work for the walls of the blow-holes would not be welded together at the usual forging or rolling temperature. In dead soft steel there does not seem to be the same objection. An ingot free from blow-holes is the proof that the steel was properly melted. We have just seen, however, that if the head of the ingot be properly designed, so that it remains liquid longer than the body, it will contain the region of segregation and also the piping."

The views of Mr. Johns regarding the small value of fluid compression, while vigorously combated by some, were as strongly supported by others. There seems to be much reason in his position, since the fluid steel itself is doubtless as incompressible as water, and the only reduction in volume to be obtained is that of the blow-holes and voids. If the steel is properly melted these are not present and there is no gain to be secured. This fact is demonstrated by the fact that the specific gravity of fluid compressed steel is the same as that of well melted steel cast in open moulds as described by Mr. Johns.

In discussing the manufacture of tires the distinguishing feature is the development of the structure entirely during the operations of manufacture, no subsequent treatment being given. This involves the most careful selection of the materials, and the steel on analysis must show not more than 0.035 of phosphorus or sulphur. The temperatures giving the best results have been experimentally determined, and these temperatures are maintained by careful supervision during manufacture. The tires are allowed to cool in the air after leaving the rolls and receive no further heat treatment. An examination of the metal shows a well-marked sorbitic structure, which it would be difficult to improve.

In the case of axles the same general care must be exercised in respect of the purity of the metal, but the manufacture is followed by oil hardening at over 1,650 degrees F. Tabulated results of tests show a yield point of about 20 tons for an ultimate resistance of 35 to 38 tons, which is a relatively high elastic limit on a moderate ultimate stress, for a steel of 0.28 to 0.30 carbon.

In the case of shafts the only heat treatment given is that of annealing to relieve the strains set up during forging, no attempt being made to alter the structure.

"That form of thermal treatment known as 'oil hardening' is very interesting, owing to its having been adopted by ordnance manufacturers for a number of years. The author has no intention of dealing with the historical side of the question. Long experience has proved that the process gives the structure and special properties required for ordinance steel, and would also seem to indicate that it still remains the best method of obtaining the desired results. For ordnance work a steel having a high elastic limit is required. This could, of course, be secured by using a higher carbon steel, heating above the critical point and cooling in air, but we have already seen that the difficulty in making large forgings increases with the carbon. Gun tubes are heavy and difficult forgings, but their tubular form, with comparatively thin walls, lends itself to a thermal treatment, in which the rate of cooling is considerably accelerated, and the required tests can be obtained easily with a 0.30 carbon steel. The intelligent use of the results given by the chemical and physical tests, enabled the process to be successfully used in the past years, and now that more light has been thrown on the structural changes that take place in the steel itself, the methods adopted remain the same. The process is simple enough, though it requires a large plant when long forgings have to be treated. They are raised to a temperature well above the critical range, quickly immersed in oil and allowed to cool. They afterwards are heated to 1,100 degrees F. and allowed to cool slowly. In practice it is better to re-heat the forgings up to 1,100 degrees F. than to stop the rapid cooling at the same point and then to cool slowly. If the forging warps or twists, it is rectified, and is then ready for the final machining. The effect of the treatment is to cause a sudden segre-

gation of the carbide of iron, not into the sharply-marked crystals of pearlite as in annealed steel, but into more indefinite areas of sorbitic pearlite. These areas are more diffused than would be the case with the pearlite of annealed steel, and would retain some of the hardening carbon, hence the raising of the elastic limit of the steel. It would also appear that the cohesion between the ferrite and sorbitic pearlite is greater than with ferrite and pearlite, probably owing to the line of demarcation being less strongly marked. In any case the steel so treated has a comparatively small grain, gives a high elastic limit with a good percentage of elongation. That these results can be obtained from a steel sufficiently low in carbon to be worked in large masses constitutes the great value of the process to the ordnance manufacturer."

BLAST-FURNACE EFFICIENCY.

THE THERMAL EFFICIENCY OF THE BLAST FURNACE CONSIDERED AS AN APPARATUS FOR THE CONVERSION OF HEAT ENERGY.

W. J. Foster—Iron and Steel Institute.

SEVERAL years ago we referred in these columns to the investigations of M. Rocour, of Liége, upon the heat balance of the blast furnace, taking the total amount of heat delivered by the fuel and the hot blast, and balancing against this the amount required to accomplish the reactions produced in the reduction of the iron from the ore. According to the computations thus made, it appeared, from a comparison of data from Belgian, German, British, and American furnaces, that the thermal efficiencies ranged from 52 to 66 per cent., or, in other words, that about two-thirds of the heat supplied was actually utilized in the production of iron.

At the recent meeting of the Iron and Steel Institute this subject was further considered in the paper presented by Mr. W. J. Foster, furnishing additional data, and, in great measure confirming the results of the researches of M. Rocour.

Mr. Foster discusses at length the influence of the hot blast, and shows that further experimental study is necessary in order that the full action of the heat in the blast may be fully understood. He then proceeds to compute the calories required for the various reductions taking place in the furnace, these being tabulated very fully in the original paper, to which the reader is referred. In general we may note that of the entire quantity of heat supplied about 22 per cent. is utilized in the reduction of iron oxide, while nearly 60 per cent. is discharged as combustible gases, the remainder being used in the reduction of silica, phosphorus, sulphur, manganese, etc., and expended in the fusion of slag, in the decomposition of the vapor of water, in driving off the bonic acid from the flux, and in the various losses, such as radiation, in the tuyere-cooling water, etc. This shows the correctness of the position which regards the blast furnace as a great gas producer, and indicates the importance of the industrial utilization of the gases which represent more than half of the heat energy supplied.

Mr. Foster proceeds to investigate the conditions which may conduce to an improvement in blast-furnace efficiency, giving especial attention to the results of rapid driving, and an increase in the temperature of the blast. It may not at first appear that the increase in the temperature of the blast can produce an increase in efficiency, since this implies an increase in the temperature of the hearth and the tuyeres.

"By increasing the temperature of the hearth, however, less blast per unit of iron made is required, for the reason that the oxides that are endothermic under ordinary conditions are converted into exothermic bodies, which is in part due to the heat absorbed by the materials on their descent to the hearth, with the result that a great amount of carbon is gasified in the hearth and bosh from the oxygen from these bodies, and, therefore, less nitrogen per unit of oxygen would be present in the furnace gases, and also a less quantity of water vapour would have to be decomposed at the tuyeres. By this it will also be seen that less gas per unit of material entering the furnace will be required, which

simply means a larger quantity of cold materials entering the mouth, with a corresponding reduction of gases; this, of course, will readily explain the reason for a reduction in the temperature of the escaping gases.

"Then comes the question of a reduction of the temperature in the gases due to rapid driving. This can be explained in a similar manner to the hot blast question, only in this case we can account for the extra heat accumulated in the hearth as due to less heat per unit of iron being lost by radiation; or, in other words, extra heat is absorbed by the descending materials that would otherwise be lost by slow driving with an increased loss by radiation, etc., which will hereafter be more particularly described when dealing with the reducing zone of the ordinary furnace. Now comes that very important question of combustible matter in the gases, which represents more than half of the fuel. This particular question opens out a very large field for future research in thermo-chemistry, which will obviously, when thoroughly understood, lead to great economy in fuel consumption of blast furnace practice; nevertheless, from a practical point of view, it appears that rapid driving increases the quantity of carbonic acid gas in the gases when leaving the furnace, which points to the fact that a rapid transfer from the reducing zone to the hearth, of the reduced iron and other materials, would result in economy in this direction, on condition that the carbon and fluxes, etc., are heated sufficiently before approaching the hearth.

"It will clearly be seen that once we can account for a saving of fuel in one particular case, there will be established a foundation that will lead to economy in every other part of the system, other than those cases previously mentioned. From time to time many authors have attempted to explain theoretically the reason why a charcoal furnace has more carbonic acid gas in the gases, and at the same time a reduction of temperature, as compared with the ordinary coke furnace, but up to the present they have not arrived at a satisfactory solution, chiefly owing to the fact that charcoal is more readily attacked by carbonic acid than coke would be. In the blast furnace we are confronted with that important question known to themal chemists as the influence of mass, and this is the question to my mind that will greatly assist us to decide the great difference between charcoal and coke furnaces. At a first glance it might be suggested, owing to the excessive volume occupied in the charcoal furnace by the fuel, that this would increase the possibility of dissolving the carbonic acid into carbon-monoxide, but, of course, we must take into consideration the properties of other materials. For example, we must consider the two very important reactions that take place in the reducing zone, namely, the reduction of iron oxides, and the splitting up of carbon monoxide by metallic iron as previously mentioned; both reactions, which are highly exothermic, develop a great amount of heat during the chemical changes. In the charcoal furnace it will be seen that the quantity of oxides of iron present in proportion to the gases is very small as compared with that of the coke furnace, owing to the excessive volume occupied by the charcoal, consequently less heat is evolved in a given quantity of matter, so that we have a less chance of bringing the temperature of the reducing zone to that point which would decompose the carbonic acid gas generated, owing to the fact that the decomposition of CO_2 on solid carbon or metallic iron is accompanied by absorption of heat, which indicates that any of these changes could only take place with the introduction of excess of external heat to the system."

That the more rapid working will conduce to increased efficiency seems to be accepted, both in theory and in the practice of the larger furnaces now so generally used in the United States.

Thus, it appears that the diminution in losses due to radiation alone would, by sextupling the speed of working, give an economy in fuel of 10 per cent., while the gain due to more efficient combustion, as indicated above, is also marked.

The scientific study of blast furnace operation, and the application of the heat balance to account for the distribution of the energy in the fuel seems sure to yield most valuable results, and it will doubtless be given increasing application in practice hereafter with corresponding influence upon technical and commercial performance.

REFRIGERATOR FREIGHT CARS.

THE SUBSTITUTION OF PORTABLE REFRIGERATING MACHINERY FOR ICE IN THE TRANSPORTATION OF PERISHABLE FREIGHT.

Warren H. Miller—Stevens Institute Indicator.

REFRIGERATION as a means of preserving perishable freight has been employed for a number of years in the United States, and the long distances over which fruit and similar products, as well as other food stuffs, are carried bears witness to the importance of the refrigerator car. By its means the products of the warmer portions of the country, as Florida or California, are transported to great cities of the Atlantic coast, enabling a continual supply to be maintained, and sustaining a great and increasing industry.

The usual method of constructing refrigerator cars has been based upon the employment of ice as a means of cooling. This limits the distance, or rather the time, of transport to the practicable conditions dependent upon the amount of ice to be carried, and upon the cost. Under such circumstances it is not surprising that attempts should be made to adapt mechanical refrigerating processes to this service, and to design a portable refrigerating machine to form a part of the car. Such an apparatus has been put into successful use in several parts of the country, and from a paper by Mr. Warren H. Miller, in a recent issue of the *Stevens Indicator* we extract some account of the construction and operation of the equipment.

A refrigerating machine consists essentially of a compressor, circulating pipes, and a condenser, the medium used being some one of several gases. When such a system is applied to a car the compressor may be driven from the axle, the circulating coils cooling the car, and the condenser abstracting the heat from the compressed gas. These seem like simple operations, but the limitations involved in their application to freight car service, and the necessity for making an apparatus which shall be absolutely independent of attention while on the road, have made the problem one of no small difficulty.

In stationary ice machines the condenser coils can be cooled by a constant supply of water, but on a freight car the limitations to the amount of water which can be carried make the condenser design one of the important elements. The principle adopted is that which has also been used of late for steam-engine condensers in localities where the water-supply is limited, the evaporative principle being employed. Theoretically a given amount of water evaporating from the outside of a pipe should be able to condense an equal amount of water within, assuming that no heat is supplied from any other source. In practice such a result cannot be attained, but the reduction in the amount of water required by use of the evaporative principle has been found to be sufficient to make the operation entirely practicable on a travelling freight car. In practice Mr. Miller states that about 200 pounds of water are required per ton of refrigeration, which has proved satisfactory.

The ice machine used in the system described by Mr. Miller is of the carbon dioxide type, and is mounted in an enclosed casing suspended beneath the car, the compressor being driven by gearing from the axle. By using an oil seal to the stuffing box the leakage is prevented, and the whole apparatus made independent of any attention except at the ends of the runs. A machine of a capacity of 1¼ tons of ice in 24 hours requires 1.3 horse-power, corresponding to about 35 pounds resistance on the rim of the car wheel.

In order to provide for the cooling at starting a certain amount of ice must be carried at first, and this is afterwards replaced by the frost which forms of the cooling coils, so that the car may remain standing for some time without risk.

"As regards care and maintenance, the only thing which requires renewal is the condenser water. There is provision for replenishing the water supply from engine hydrants, but in practice a car does well that makes two Chicago-New York trips per month, or its equivalent. Rain shed from the roof invariably fills the condenser tank to overflowing, sometimes as often as four times a week, and it is rare that a

car has to be taken to a locomotive hydrant to be filled. Oil requires renewal about once in eight months, and an extra drum of carbonic acid gas must be put in once in three months."

Practical experience with these cars has been such as to show that their use in regular service is altogether possible, and the cost of operation is necessarily much lower than that of the ordinary refrigerator cars using ice alone. The cost of the power is small, and it can be shown to be more than counterbalanced by the increase in capacity of the cars for merchandise, owing to the reduction in the space required for ice, while the allowance for repairs and depreciation, while yet to be determined by experience, cannot be great with such a simple apparatus. Doubtless extended experience will result in improvements in the machinery, and its use upon various railroads in the United States will determine whether this more scientific method will replace the older and cruder, as well as more expensive plan of carrying sufficient ice to last the entire trip.

IMPROVED TOOL STEELS.

EXPERIENCE IN THE RAILROAD SHOP SHOWING RELATIONS BETWEEN STEELS, MOTORS DRIVING, AND MACHINE TOOLS.

W. R. McKeen—Railway Master Mechanics' Association.

ABOUT a year ago we reviewed in the pages some of the results which had been attained in the shops of the Union Pacific Railroad Company at Omaha, and now we have a very full and valuable account of practical investigations made in the same works by Mr. W. R. McKeen, the Superintendent of Motive Power, and presented at the Saratoga meeting of the American Railway Master Mechanics' Association.

The value and importance of the tests lies largely in the fact that they represent actual practical work in the railway shop.

"The tests were not made on specially devised castings or forgings, nor were any machines arranged in special reference to these tests. All observations were made on work going through the shop during regular working hours and on actual locomotive parts being put through the shop; these same parts being afterward applied to locomotives. The tests were conducted according to the directions of the chemist and engineer of tests, and under the supervision of the general shop demonstrator; the electrical readings were taken by the local electrician, and the machines were handled in their regular course by the mechanics assigned to each class of work. Turning and planing tools were forged and tempered by the regular toolsmith, and the twist drill and milling cutters were made in the local toolroom. Under these conditions a much fairer comparison as to the actual benefits obtained from alloy tool steel in regular shop practice can be made than where special test conditions are followed."

Three lines of comparison were taken, namely: First, the speed, cut and feed; second, the durability of the tools; third, the amount of power expended in keeping a tool up to its proper capacity. The first depends upon the volume of output; the second on the quality of steel and manufacturer's and toolmaker's skill; the third being closely related to the first and dependent on it.

Mr. McKeen rightly calls attention to the fact that air-hardening steels have been in the field for a long time, and that these, although by no means the equal of the modern high-speed steels, are superior to the older carbon steels. He well remarks that the ordinary air hardening tools may be considered as holding a position midway between the old carbon steels and the new high-speed alloy steels. The comparisons made in the paper, however, are between the old carbon steels and the modern high-speed alloy steels, leaving the ordinary air-hardening steels out of consideration.

The tests made in the Union Pacific Shops at Omaha consisted in comparative trials made between the two kinds of tools upon the operations of planing, lathe work, milling, and drilling. The results of the trials are tabulated in the paper, but we give here some account of the conditions

of the tests, with a general summary of the results.

The planing tests consisted in roughing out side rods of soft steel, the data taken being the amount of metal removed and the time required for actually removing the metal, not including the time used in setting work nor in the reverse travel of the planer.

Apart from the far greater efficiency of the new steel, as shown in the summary, it may be noted that the alloy tool kept its edge throughout the tests, and was in condition to do two or three hours more work without regrinding. Regrinding is found to be required, not because the cutting edge is destroyed, but from the hollowing out of the top of the nose of the tool by the surface friction of the metal removed. Any attempt to use carbon steel at the same speed showed the impossibility of doing so, the cutting edge being completely burnt off at the end of three-quarters of a minute, the nose of the tool being destroyed for half an inch, making any further cutting impossible. In order to maintain a cutting edge it has been found necessary to maintain only about one-half the depth of cut practicable with the alloy steel. Corresponding results were obtained with the other operations, both as to the amount of metal removed and the power required to perform the machining operations.

Apart from the gain in the actual machining operations, Mr. McKeen calls attention to the saving effected in the one matter of tool grinding. In the case of the carbon-steel tool the operation of regrinding had to be performed three times for each tire turned, this operation requiring fifteen minutes each time, counting the time walking to and from the emery wheel; while the high-speed steel tool lasts through the entire job with but a single grinding, a gain in time directly due to the steel, in addition to the higher speed of the actual operation of turning.

A summary of the tests follows:

Planer Tests.—Alloy steel necessitated 20.9 horse-power removing 780 lbs. of metal per hr., as against 15.9 horse-power with carbon steel and only 288 lbs. metal removed per hour.

Wheel Lathe Tests.—Alloy steel necessitated 6.5 horse-power with 96 lbs. metal removed, as against 2.3 horse-power with carbon steel and 15 lbs. metal removed.

Lathe Tests (*Cylinder Bushing*).—Alloy steel necessitated 11.6 horse-power and 180 lbs. of metal removed, as against 10 horse-power with carbon steel and 54 lbs. metal removed.

Milling Machine Tests (*Locomotive Shoe*).—Alloy steel necessitated 4.4 horse-power and 195 lbs. metal removed, as against 3.1 horse-power with carbon steel and 82 lbs. metal removed.

Radial Drill Tests (*Cast Iron Blocks*).—Alloy steel necessitated 5.6 horse-power and 88 lbs. metal removed, as against 2.6 horse-power with carbon steel and 51 lbs. metal removed.

"Improved, or alloy, tool steel has increased the output of railroad shop machines from 25 per cent. to 100 per cent., and in certain cases as much as 200 per cent., and while, with increased output, the horse-power required to turn out work has increased, this increase of horse-power absorbed is not in proportion to the increase in output. The use of alloy steel, where machines have been driven by motors already worked up to capacity, will necessitate 25 per cent. to 50 per cent. larger motors, as has ben evidenced by our own experience.

"The strength and capacity of our present machines are almost universally overtaxed, for the reason that they were not designed for the new conditions. Our experience has shown conclusively the necessity for heavier and more substantial design of all machines; steel pinions instead of cast iron; longer bearings for shafts and increased diameter. Furthermore, it clearly demonstrates the economy of scrapping old-style machinery.

"Our best record on locomotive driving wheels is a 56-in. pair in 1 hr. and 27 mins. Steel-tired car wheels formerly required from 5 hours up to turn and true to size; the present minimum time in our shops is 55 minutes, the average being about two hours. While these reductions in time are largely due to the alloy steel, improved shop methods and system have also entered largely into the economies mentioned."

It is this last feature, namely, the addi-

tional shop economies which follow in the wake of the introduction of the new tool steels which constitute a most important feature of the whole movement.

It has been shown that the actual time occupied in machining even a complicated piece forms but a small proportion of its time in passing through the shop. With the introduction of the rapid gait on the machine tools themselves, however, the pace is accelerated all along the line. In the modern shop the old time deliberate movements are conspicuous by their absence, and a new spirit of life and activity appears on all sides. In a large number of cases the men at the tools are working under some form of piece or premium wage system, and they soon find that their output, while largely increased by the use of the rapid-cutting tool is also dependent to a great extent upon the promptness with which they are served. Any dawdling either with laborers, cranes, or other handling appliances is quickly detected by them, and it has often been found that with the improved tools and methods it is necessary to reorganize the entire system of handling materials in order that the machine tools may be kept supplied with work.

Such tests and records as have been made by Mr. McKeen are most valuable and interesting, but it would also be most desirable to have data as to the total gain in product due to the introduction of the new steels, including the increase due to the more rapid pace of the establishment.

ENGINEERING AND THE FOUNDRY.

THE RELATION OF THE FOUNDRY TO THE WORK OF VARIOUS DEPARTMENTS OF ENGINEERING PRACTICE.

Dr. R. Moldenke—American Foundrymen's Association.

CAST IRON has had various ups and downs as a material of engineering construction, and having fallen from its once high estate it has again be rehabilitated to a great extent by the application of scientific principles to its production and use. We do not expect to see cast-iron shafting, nor is it probable that cast iron will be again used for bridge construction, but the intelligent application of that kind of engineering which Nasmyth defined as "common sense applied to the use of materials" is undoubtedly being given to the foundry and its products. In a paper presented at a recent meeting of the American Foundrymen's Association by Dr. Richard Moldenke the relation of the foundry to various departments of engineering work is discussed in a very satisfactory manner, and some abstract of the paper is here given:

"It is not so very long ago that when an engineer had to do some detailing in which cast iron was used, he simply figured on a strength of 10,000 pounds per square inch, and let it go at that. To-day more is required of a man up in his profession. Where the use of cast iron is advantageous, it makes quite a difference whether ordinary cupola metal is employed or the highest grade gun metal. In other words, the engineer should know something of the several kinds of cast iron made, how they are made and how used to the best advantage.

"The best indication of this modern tendency is seen in the recent presentation of specifications for testing cast iron and finished castings. These arose from the demand of the buyer to know what he is paying for, and as a consequence he is learning to specify his wants more clearly. Then also there is the desire of the engineer to acquaint himself with a material he is called upon to inspect for the buyer, and pass upon as good for the purpose or not. Finally, the foundryman himself, in his most broad-minded form, has always been desirous of giving the customer the best he can make, and indeed must do this or find his product replaced by the malleable or steel casting. All these tendencies have brought about a general getting together of those most interested, with the result that for the first time in the history of the iron industry has a common ground been found for working specifications governing the testing of cast iron and its products."

Dr. Moldenke examines the extent to which engineers in different departments of work need to be informed upon the vari-

ous properties of cast iron and its different applications.

"It will be easily seen how the civil engineer will be specially interested in cast iron going into railroad and bridge construction, whether for actual working parts or merely the ornamental end. Similarly in the designs of buildings, whether terminals or skyscrapers. The mechanical engineer naturally has more to do with cast iron and runs through the whole gamut in his daily practice. In the railroad service he deals with malleable as well as gray iron castings in his car construction. The locomotive adds some steel castings to these. Then the cast iron car wheel will give him enough to think of, as will be seen from the specifications alone. In the machine shop, rolling mill and in the foundry itself, the mechanical engineer should be a master in adapting this metal, in its various forms, to the purpose in hand, and hence he cannot learn too much of the production of all classes of castings, gray, chilled, malleable and steel.

"Finally there is the mining engineer, who has probably to suffer most from breakdowns with iron castings, as he is always isolated and must transport his repair parts great distances. He also should know something of foundry practice, as he could oftentimes help himself by "burning on" a broken piece, if he but knew how to rig up a temporary cupola out of an old boiler shell, and drive compressed air into the charge."

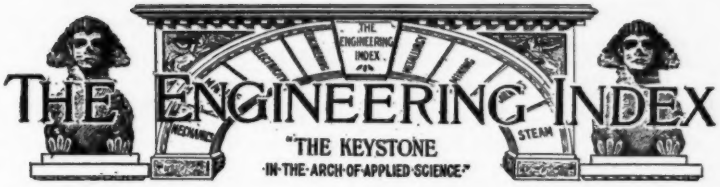
In making specifications for cast iron the engineer has to consider both pig iron and foundry castings, and these should be considered separately. The grading of the pig iron is based upon the content of silicon and sulphur, the best grades having the most silicon and the least sulphur, the ferrosilicons forming a class by themselves. It does not follow that a low-grade pig should be rejected, since the volume may be proportionally adjusted and the material suitably improved by mixing.

The character of castings may be graded by a suitable application of correct methods of testing.

"This is the result of years of thought and experiment by engineers' and foundrymen's associations, as well as independent investigators, thoroughly digested by those who were most active in this work, and the result approved by a majority of the cast-iron experts of the country. The following principles were recognized: In America we prefer to judge a casting which cannot be tested to destruction, by the quality of the iron entering into it. That is to say, by pouring the melted iron into test bars, under standard conditions, and then testing these bars to form conclusions therefrom. Next it is recognized that these bars should be made of as large a section as possible, consistent with a proper structure, or constitution of the iron, to avoid the artificial influences of damp molding sand, variations in pouring temperature, cooling strains, etc. Also to keep the tests within the limits of the ordinary testing machines found in our foundries.

"Then comes the cross-section of the bars, the round form being better than the rectangular, as it avoids the artificial cooling at the corners. Next the manner of casting. Experience has shown that a bar cast flat, when tested in the position as cast gives different results from those obtained when the bar is reversed. Hence the importance of casting the bars vertical. The refinement of the bottom pour, though giving better results, is too cumbersome for commercial use. A suitable rotation in the casting of these bars is necessary, so that the results may be representative. The bars are not to be tumbled, as this would remove casting strains, and make the material artificially strong when compared with the castings themselves, which are not so treated. Finally comes the testing of the bars themselves, which experience has shown to be best accomplished by placing them upon supports 12 inches apart and breaking by applying the load at the center. The deflection is also noted."

Wherever there is a quiescent load. which requires a material with high crushing strength to sustain it, there cast iron will be found most valuable. Wherever art constructions of the engineer, there cast iron is essential. The fact that last year some 3,600,000 tons of castings were made in America shows what this industry means to the engineering and building work of the United States.



The following pages form a DESCRIPTIVE index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every article.

(1) The full title,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published.

We supply the articles themselves, if desired.

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer and works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of any article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the journals indexed are given.

DIVISIONS OF THE ENGINEERING INDEX.

CIVIL ENGINEERING 843
ELECTRICAL ENGINEERING 848
GAS WORKS ENGINEERING..... 854
INDUSTRIAL ECONOMY 855
MARINE AND NAVAL ENGINEERING..... 857
MECHANICAL ENGINEERING 858
MINING AND METALLURGY..... 867
RAILWAY ENGINEERING 872
STREET AND ELECTRIC RAILWAYS..... 876

CIVIL ENGINEERING

BRIDGES.

Approaches.

The Mingo Bridge Approaches. This bridge carries a double-track railroad across the Ohio River near Mingo Island. Begins an illustrated detailed description of the construction work. 2200 w. Eng Rec—June 25, 1904. Serial. 1st part. No. 63555.

Arch.

The Luxembourg Bridge (Le Pont de Luxembourg). R. Bonnin. A well illustrated account of the construction of the great twin masonry arch of 84.65 metres span at Luxembourg. 3000 w. Revue Technique—May 25, 1904 No. 63231 D.

Articulations.

Articulations in Granite for Bridges. Describes methods successfully carried out in Wurtemberg and Saxony in which articulations of a metallic character are excluded and the same purpose accomplished by means of arch stones or concrete voussoirs in direct contact with one another. 1100 w. Engr, Lond—June 10, 1904. No. 63441 A.

We supply copies of these articles. See page 878.

Bascule.

A Short-Span Bascule Bridge in New York City. Brief illustrated description of the bridge over the Mott Haven Canal at 135th street. 800 w. Eng Rec—June 18, 1904. No. 63421.

Design.

The Detailed Design of a Railroad Bridge. William H. Burr and Myron S. Falk. An exposition of the design of a steel railroad truss bridge showing the application of engineering science in this field. Ills. 9000 w. Sch of Mines Qr—April, 1904. No. 63338 D.

Girder.

A Three-Track Beam-Floor Girder Bridge. Illustrates and describes the principal structural pecularities of a bridge in Newark, N. J. 1300 w. Eng Rec—June 18, 1904. No. 63420.

Railway Bridge.

Railway Bridge Over the Clyde at Uddington. Two-page plate and illustrated description of a new bridge for carrying the Caledonian main line of railway between Glasgow and Carlisle. 1700 w. Engng—June 17, 1904. No. 63497 A.

Substructure.

The Substructure of the Fraser River Bridge. Illustrates and describes the substructure of this bridge in British Columbia, and its construction. 3300 w. Eng Rec—May 28, 1904. No. 63048.

Suspension.

Conway Suspension Bridge. An account of the reconstruction of this historic bridge in Wales, designed by Telford nearly eighty years ago. 1800 w. Engr, Lond—May 20, 1904. No. 63017 A.

Vauxhall.

The New Vauxhall Bridge. Reviews the history of the rebuilding of this bridge and the cause of the delay. Ills. 4700 w. Engng Rev—June, 1904. No. 63539 B.

Viaduct.

The Viaur Viaduct. Daniel Bellet. Illustrated detailed description of this viaduct in the south of France. It has a total length of 1,509 feet; the central arch a span of 721 feet 9 inches; the rails are at height of 377 feet above the river. 4000 w. Trac & Trans—June, 1904. No. 63377 E.

Woodsville.

The Woodsville Railroad and Highway Bridge. Illustrates and describes this bridge across the Connecticut River which is the sixth built at this point. 2500 w. Eng Rec—June 25, 1904. No. 63557.

CONSTRUCTION.

Domes.

Notes on the Stresses in Framed Spires and Domes. W. Dunn. An explanation of the method of determining the nature of the stresses, giving stress diagrams. 7500 w. Jour R Inst of Brit Archts—May 21, 1904. No. 63382 B.

Fire Protection.

Necessary Reforms in the Fire Protection of Theatres (Ueber die Feuersicherheit der Theater und die Notwendigen Reformen). Hermann Helmer. With plans of a number of existing structures, and suggestions for an improved design. 5000 w. 1 plate. Zeitschr d Oesterr Ing u Arch Ver—May 20, 1904. No. 63237 D.

Some Lessons of the Baltimore Conflagration. The principal part of a report submitted to the Insurance Engineering Experiment Station by Prof. C. L. Norton and Joseph P. Gray. 2500 w. Eng News—June 2, 1904. No. 63084.

Platform.

Arch Trusses for Aerial Circus Platform. Gives plans and details of arch trusses for aerial circus at Luna Park, Coney Island, New York. 1100 w. Eng Rec—June 18, 1904. No. 63422.

Reinforced Concrete.

A Factory Building with Reinforced Concrete Wall Girders. Illustrated description of construction work at Passaic, N. J. 1300 w. Eng Rec—June 18, 1904. No. 63423.

A French Breaking Test of Reinforced Concrete Bridge Trusses. Leon S. Moisseiff. Describes the construction and breaking test of the bridge built by the Paris-Orleans Ry. Co. for this purpose. Ills. 4000 w. Eng Rec—June 4, 1904. No. 63101.

An All-concrete Grand-Stand. Illustrated detailed description of the recently completed grand-stand for the athletic field at Washington University, St. Louis. 1000 w. Eng Rec—May 28, 1904. No. 63047.

A Reinforced Concrete Store Building in Chicago. Illustrated detailed description of the construction of a seven-story building. 1200 w. Eng Rec—June 4, 1904. No. 63103.

Concrete Steel Construction. Leonard C. Wason. Abstract of a lecture before the Civ. Eng. Soc. of W. P. I. Information concerning cements and their manufacture, their strength, elasticity, &c., with points in construction work, showing that concrete steel is an economical and durable material. Ills. 3300 w. Jour Worcester Poly Inst—May, 1904. No. 63316 C.

Design for Reinforced Concrete Bins for Grain Elevators. Illustrated description of a rectangular bin construction with supporting columns. 1500 w. Eng News—June 23, 1904. No. 63486.

We supply copies of these articles. See page 878.

Reinforced Concrete in Building Construction. Condensed from a paper read by Emile G. Perrot before the School of Architecture, University of Pennsylvania. Considers various important questions in regard to its reliability, its advantages, &c. 2800 w. Eng Rec—May 28, 1904. No. 63045.

Reinforced Concrete Piles with Enlarged Footings for Underpinning a Building. J. Albert Holmes. A brief description of work in Boston, underpinning exterior walls of a building erected on filled land. Ills. 500 w. Eng News—June 16, 1904. No. 63406.

Some Phenomena of the Adhesion of Steel and Concrete. J. W. Schaub. Extract from a lecture on "Reinforced Concrete" delivered at Armour Institute, Chicago. Gives results of experimental investigations. 1300 w. Eng News—June 16, 1904. No. 63405.

Roofs.

Developing the Surface of Spherical Roofs by Calculation. Jas. Clark. Describes the method used by the writer. 700 w. Am Mach—June 23, 1904. No. 63510.

Roof Trusses.

A Novel Method of Erecting the Roof Trusses of the 71st Regiment Armory, New York City. W. T. McCarthy. Illustrates and describes an economical and novel method of erecting a riveted truss of long span. 1500 w. Eng News—June 16, 1904—No. 63404.

Tunnels.

Italo-Swiss Alpine Tunnels. Outlines the various schemes proposed and under construction for connecting Italy and Switzerland, and tunneling the Alps and Apennines. 1800 w. Engr, Lond—June 10, 1904. No. 63437 A.

Notes on the Early History of the Hudson River Tunnel. S. D. V. Burr. An account of early work on this tunnel, describing also some of the peculiar physical characteristics of the silt composing the bed of the river. 1800 w. R R Gaz—June 3, 1904. No. 63107.

The Hudson River Tunnel. S. D. V. Burr. An illustrated article comparing the original methods with those now employed. 3000 w. Ir Age—June 2, 1904. Serial. 1st part. No. 63058.

MATERIALS OF CONSTRUCTION.

Cement Plant.

Cost of Building and Operating a Portland Cement Plant. Considers things that cause variation in the cost, and gives information concerning a mill with an output of 2000 barrels per day. 3000 w. Munic Engng—June, 1904. No. 63323 C.

Efficiency of Rotary Cement Kilns. Dr. W. Michaëlis, Jr. Illustration, with description of a patent of the writer's for increasing the capacity of a rotary kiln under the wet process. 1600 w. Eng Rec—June 4, 1904. No. 63104.

Cement.

Standard Specifications for Cement. Gives the specifications ordered sent out for approval by the Am. Soc. for Testing Materials. 1100 w. Eng Rec—June 25, 1904. No. 63556.

Tests of Cements. J. E. Howard. Begins an account of the tests made at the Watertown Arsenal. 3300 w. Am Archt—June 18, 1904. Serial. 1st part. No. 63445.

Concrete.

The Quality and Consistency of Concrete for Concrete-Steel Work. Editorial discussion of the importance of excellence of materials and manufacture in this work and the proper composition, and the practical advantages of wet mixtures. 1600 w. Eng News—June 9, 1904. No. 63180.

Concrete Blocks.

Concrete Block Manufacture. Considers the underlying principles which should govern the development of this industry 1800 w. Munic Engng—June, 1904. No. 63322 C.

Concrete Mixer.

Concrete Mixer with Automatic Measuring Device. Illustrated detailed description of an invention of Henry Campbell, of Milwaukee, Wis. 1500 w. Eng News—June 2, 1904. No. 63083.

Nails.

A New Form of Nail (Un Nouveau Clou). R. Wittebolle. A comparison of the weak features of various forms of nails, showing the advantages of a special form of chisel point. 2500 w. Revue Technique—May 25, 1904. No. 63232 D.

Plaster.

The Setting of Plaster of Paris (Etude des Conditions de Prise du Platre). Louis Périn. A description of the "Prisometre" devised by the writer to determine the rate of setting of plaster. 1000 w. Génié Civil—June 4, 1904. No. 63229 D.

Stone Working.

Stone-Working Machinery. Illustrated description of a new type of machine for surfacing stone; especially adapted for granite. 800 w. Engr, Lond—June 10, 1904. No. 63442 A.

MEASUREMENT.

Surveys.

Hydrographical Surveys, 1903. Reviews the chief points of interest in connection with the operations of the British sur-

We supply copies of these articles. See page 878.

veying vessels. 2500 w. Engr, Lond—May 27, 1904. No. 63131 A.

Topography.

The Use of Stereoscopic Images for the Construction of Topographic Plans (Sur l'Emploi d'Images Stéréoscopiques dans les Construction des Plans Topographiques). A. Laussedat. Describing a system of exaggerated stereoscopic photography for use in photographic surveying. 2000 w. Comptes Rendus—May 30, 1904. No. 63256 D.

MUNICIPAL.

Baltimore.

Progress of Plans and Work for Rebuilding Baltimore. Daniel J. Hauer. Gives a general synopsis of the lines on which the city is to be rebuilt, showing the progress. Map. 2400 w. Eng News—June 2, 1904. No. 63078.

Pavements.

Neglected Details in Brick Pavement Construction. Ira O. Baker. Read before the N. B. M. A. Convention. Discussses the width of pavement, subgrade, foundations, cushion, brick, and joint filler. 5000 w. Brick—June, 1904. No. 63481.

Refuse.

Refuse Destruction by Burning, and the Utilization of Heat Generated. C. Newton Russell. Treats the practical side of the question, describing the works with which the writer is associated. Ills. 4800 w. Inst of Mech Engrs—June, 1904. No. 63332 D.

The Burning of Town Refuse. George Watson. With special reference to the destructors at Brussels, West Hartlepool, Moss Side, and Westminster. Ills. 9000 w Inst of Mech Engrs—June, 1904. No. 63332 D.

Roadways.

Roadways: Their Relationship to the Various Public Services. A. E. Broadberry. Read before the Inst. of Gas Engrs. Suggestions for an organized arrangement of roadways in their relation to sewers, surface drainage, water and gas supply, telephones, &c. General discussion. 4500 w. Gas Wld—June 11, 1904. No. 63495 A.

Sewage Disposal.

Adaptability of the Massachusetts Method of Intermittent Sand Filtration to Sewage Disposal Problems in Other States. F. Herbert Snow. Discusses the part the Massachusetts State Board of Health has taken in placing the art of sewage disposal on a scientific basis, and considers four typical problems outside of the State. Discussion, including also Mr. Goodnough's paper. 11000 w. Jour Assn of Engng Soc's—May, 1904. No. 63394 C.

A Description of Sewage Disposal Systems in Massachusetts. X. Henry Goodnough. Reviews the progress of sewage disposal in the State, and gives brief illustrated description of the more important plants. 4700 w. Jour Assn of Engng Soc's—May, 1904. No. 63393 C.

New Sewage Works at Glasgow. Illustration, with description of some of the interesting features of this plant, which is the second largest in the world. 2000 w. Engr, Lond—June 3, 1904. No. 63372 A.

Sewage Disposal. Prof. W. S. Leavenworth. Reviews the various methods in use. 4500 w. Dom Engng—May 25, 1904. No. 63018 C.

The Use of the Septic Tank in Connection with Sewage Disposal Works. Frank A. Barbour, with discussion. Refers to several plants, and concludes that facts justify the further use of this system. 18000 w. Jour Assn of Engng Soc's—May, 1904. No. 63395 C.

Sewerage.

Extensions of the Brooklyn Sewerage System; Foster Avenue Trunk Sewer. Describes two sections extending eastward from the Sixtieth street sewer. 2400 w. Eng Rec—May 28, 1904. No. 63049.

The Scheme of the Extensions of the Brooklyn Sewerage System. Map, with a statement of the general scheme, based upon the report of the chief engineer. 3300 w. Eng Rec—June 11, 1904. No. 63189.

Streets.

The Streets and Street Plan of Paris; A Lesson in Municipal Esthetics. Remarks on the beauty of Paris, comparing London, New York and Washington. 2000 w. Eng News—June 2. 1904. No. 63082.

Waste.

The Utilization and Disposal of Municipal Waste. William F. Morse. Considers the disposition of garbage, ashes, refuse and street sweepings in large cities. Ills. 5200 w. Jour Fr Inst—June, 1904. No. 63340 D.

WATER SUPPLY.

Analysis.

Methods and Interpretation of Water Analysis. A. Robin. Shows the unreliability of chemical analysis alone, considers the bacteriological examination, and that a proper combination of laboratory methods is needed for an accurate conclusion to be reached. 4800 w. San—June, 1904. No. 63154 D.

Antwerp.

The Antwerp Water Works. An illustrated detailed description with history of the water supply of this important port.

We supply copies of these articles. See page 878.

3000 w. Engng—May 27, 1904. Serial. 1st part. No. 63127 A.

Aqueducts.

Repairs and Reconstruction on the Old Croton Aqueduct. Describes this aqueduct which was put into service in 1842, reviewing the repairs made at different times, and those now being made to enable it to resist an external pressure of twenty pounds per square inch. 3000 w. Eng Rec—June 18, 1904. No. 63417.

Baden.

The Water Supply and Sewerage of Baden (Die Wasserleitung und Kanalisation von Baden). Thomas Hofer. A detailed account of the new water supply of Baden, Austria, and of the recently constructed drainage system. Two articles, two plates. 8000 w. Zeitschr d Oesterr Ing u Arch Ver—May 27, June 3, 1904. No. 63237 each D.

Derwent Valley.

Quarries and Works of the Derwent Valley Water Board. Illustrated description of one of the largest schemes for water supply in England, which is to serve the towns of Leicester, Derby, Sheffield and Nottingham. 3300 w. Quarry—June, 1904. No. 63359 A.

Filtration.

Concrete Work on the Washington Filtration Plant. E. D. Hardy. An illustrated description of the work of placing the concrete masonry. 1200 w. Eng Rec—June 25, 1904. No. 63554.

Fire Service.

Water Service at the Baltimore Fire. Extracts from a paper before the Am. Water Works Ass'n, by Alfred M. Quick. Describes the distribution system in Baltimore, and discusses whether any water service could successfully cope with such an emergency, the effectiveness of private fire services, and the possibility of the waste in buildings destroyed by the fire temporarily crippling the service. 5000 w. Eng Rec—June 11, 1904. No. 63187.

Irrigation.

Government-Irrigation Work. Guy E. Mitchell. An illustrated article describing proposed work, for which $2,600,000 have been appropriated. 1200 w. Sci Am Sup—June 11, 1904. No. 63306.

Meters.

Effect of Meters, New Storage Reservoir and Yield of Watershed, Newark Water Works. Statement and diagram from the report of M. R. Sherrerd, showing the influence of the compulsory introduction of about 4000 meters. Also information concerning the new Cedar Grove reservoir, and the development of the watershed. 2000 w. Eng Rec—June 11, 1904. No. 63191.

Test of a 30-inch Premier Meter at the Testing Plant of the National Meter Co., Arthur S. Tuttle. Description of the test, with illustrations of the testing plant in South Brooklyn, N. Y. The testing weir is fully equipped with facilities for accurately measuring the flow of water. 1700 w. Eng News—June 16, 1904. No. 63407.

New Bedford, Mass.

The Quittacas Pumping Station and Other Features of the New Bedford Water Works. Reviews the history of the water-works system, describing and illustrating the new works. 5000 w. Eng Rec June 25, 1904. No. 63558.

New York.

Air-Lift Pumping Machinery at the Inverted Siphon of the New Croton Aqueduct, New York City. Begins an illustrated detailed description of the pumping apparatus. 3300 w. Eng Rec—May 28, 1904. Serial. 1st part. No. 63046.

The Installation of a Pneumatic Pumping Plant Arthur H. Diamont, Jr. Illustrating and describing the Harris pneumatic pumping plant for emptying the Harlem river siphon of the Croton Aqueduct, New York. 5800 w. Pro Am Soc of Civ Engrs—May, 1904. No. 62996 E.

Pumping Station.

A Small Concrete-Steel Sewage Pumping Station, at Newton, Mass. Illustrated description of an interesting plant for a suburb of Boston. 1500 w. Eng Rec—June 11, 1904. No. 63192.

Reservoirs.

Lake Cheeseman Dam and Reservoir. Discussion of the paper by Charles L. Harrison and Silas H. Woodard. 7200 w. Pro Am Soc of Civ Engrs—May, 1904. No. 62999 E.

Round Hill Dam, Spring Brook, Pennsylvania. Marshall O. Leighton. Describes the construction work, all of which was performed by the water supply company's own laborers working by the day. Ills. 1200 w. Eng Rec—June 11, 1904. No. 63188.

St. Louis.

The Water Supply System of St. Louis. W. E. Rolfe. An illustrated article giving the history, general outline and description of interesting features, with facts related. 5000 w. Eng Rec—June 4, 1904. No. 63097.

Settling.

The Automatic Removal of Solids from Water. Walter J. May. On the use of subsidence classifiers. 1000 w. Prac Eng—May 27, 1904. No. 63041 A.

Underground Water.

The Flowage of Underground Water.

We supply copies of these articles. See page 878.

John Wellington Finch. Extracts from a paper read before the Colorado Sci. Soc. Considers the ideal direction of movement, passage through the rocks, barriers to flow, the zonal disposition, &c. 4700 w. Ores & Met—June 15, 1904. Serial. 1st part. No. 63444.

Water Treatment.

The Treatment of Moorland Water to Prevent Action Upon Lead Pipes. C. Clemesha Smith and E. M. Chaplin. Abtract of a paper before the British Water Works Ass'n. A description of methods tried and the conclusions and cost. Ills. 4500 w. Eng News—June 23, 1904. No. 63487.

WATERWAYS AND HARBORS.

Belgium.

Navigable Waterways of Belgium. Information from the report of Mr. Hertslet, the British Consul General at Antwerp. 1500 w. Engr, Lond—May 27, 1904. No. 63133 A.

Dock Plant.

Middlesbrough Dock Electric and Hydraulic Power Plant. Vincent L. Raven. Gives the particulars of the installation and of the tests made at this dock on the North Eastern Railway, comparing hydraulic with electric. Ills. 5000 w. Inst of Mech Engrs—June, 1904. No. 63331 D.

Electric Traction.

Electric Equipment for Cornwall Canal. F. H. Leonard, Jr. Briefly outlines the hydraulic and generating equipment, and describes the lighting, lockages and weirs. 6 plates. 5000 w. Can Soc of Civ Engrs, Adv Proof—March 24, 1904. No. 63326 D.

Electrical Equipment for Cornwall Canal. F. H. Leonard, Jr. Read before the Can. Soc. of Civ. Engrs. Illustrates and describes the arrangements for power and lighting. 4500 w. Elec Rev, N. Y.—June 11, 1904. No. 63183.

The Use of Electricity on the Lachine Canal. L. A. Herdt. Brief description of this canal, showing its importance, and of the application of electricity for lighting the canal, locks, and bridges, for heating the power house and lock cabins, to open and close the lock gates, sluice valves and waste weirs, and to operate the swing bridges. Ills. 2500 w. Can Soc of Civ Engrs, Adv Proof—March 24, 1904. No. 63325 D.

Panama.

Health Conditions on the Isthmus of Panama. Dr. W. C. Gorgas. A statement of the sanitary conditions explaining the dangers to health and discussing the probability of keeping them under control 2200 w. Eng Rec—June 4, 1904. No. 63098.

MISCELLANY.

Drainage.

Tile Drainage. F. L. Knight. On Locating systems of tiling and matters related. 5000 w. Brick—June, 1904. No. 63480.

Land Changes.

Emergence and Submergence of Land. Abstract of an address by Sir Archibald Geikie, on the evidence supplied by the British Isles as to the problem of the causes of changes in the relative levels of sea and land. 6800 w. Nature—June 2, 1904. No. 63194 A.

Land Slide.

A Phenomenal Land Slide Discussion of paper by D. D. Clarke on the slide affecting the reservoirs of Portland, Oregon. 5500 w. Pro Am Soc of Civ Engrs —May, 1904. No. 62998 E.

ELECTRICAL ENGINEERING

COMMUNICATION.

Alarms.

Selective Alarm Calls (Die Stufenwecker). J. Baumann. A description of an electric alarm call system for telephone lines by which any one subscriber on a party wire may be called without disturbing the others. 2500 w. Zeitschr f Electrotechnik—May 15, 1904. No. 63-263 D.

Cables.

Multiple Telephone Cables with Air Insulation (Die Fabrikation Mehradriger Telephonkabel mit Luftisolation). J. Schmidt. Giving details of construction and methods of manufacture of several German makers. 3000 w. Zeitschr f Elektrotechnik—May 29, 1904. No. 63-264 D.

Space Telegraphy.

A Ferraris Field Detector of Hertzian Waves. Prof. Riccardo Arnò. Describes work performed in the electrical laboratory of the R. Instituto Tecnico Superiore of Milan. 1700 w. Elect'n, Lond—June 3, 1904. No. 63366 A.

Telegraphy.

The Telegraph Operator in the Railroad Service. John B. Taltevall. Read at meeting of Assn. of Ry. Tel. Supts. On instruction needed by operators to increase their efficiency. 1600 w. Ry Age—June 24, 1904. No. 63573.

We supply copies of these articles. See page 878.

Telephony.

Some Telephone Problems in Farming Communities. Howard S. Knowlton. Considers some of the difficulties to be met in farming districts, giving the record of a Colorado Telephone Co. as an example. 3500 w. Elec Wld and Engr—June 11, 1904. No. 63198.

The Use of Modern Telephones as Applied to Railroads. B. A. Kiser. Read before the Assn. of Ry. Tel. Supts. Shows the work actually being done on one of the railroads by the use of the telephone. 1500 w. Ry Age—June 24, 1904. No. 63574.

DISTRIBUTION.

Cables.

Protection of Cables from Arcs Due to the Failure of Adjacent Cables. W. G. Carlton. Briefly considers the methods of protection used for high-pressure cables, particularly in manholes. 1300 w. Trans Am Inst of Elec Engrs—June 21, 1904. No. 63351 D.

Capacity.

The Electrostatic Capacity of Wires. George D. Shepardson. Considers the things upon which the capacity of a wire depends, stating important cases. 2000 w. Reprint from Year Book of the Soc of Engrs., Univ. of Minnesota—Vol. XII, 1904. No. 63328 D.

Fuses.

A New Safety Fuse for High Pressure Currents (Eine Neue Schmelzsicherung für Hochspannungsstromkreise). F. Collischonn. The wire fuse is enclosed in a glass tube filled with oil. 3000 w. Elektrotech Zeitschr—June 9, 1904. No. 63210 B.

Losses.

Lost and Unaccounted-for Current. C. W. Humphrey. Read before the Nat. Elec. Lgt. Assn. An explanation of the calculations of losses, known and unknown, for alternating and direct-current circuits, giving records of some of the results obtained. 3000 w. Elec Rev, N. Y.—June 4, 1904. No. 63096.

Networks.

An Analytical and Graphical Method of Computing Closed Networks (Eine Analytische und Graphische Methode zur Berechnung von Geschlossenen Leitungsnetzen). P. M. Verhoeckx. Applying the method of determinants to the transformation of the original equations; with practical examples. Two articles. 6000 w. Zeitschr f Elektrotechnik—May 15, 22, 1904. No. 63262 each D.

Regulation.

The Distribution of Electric Power from Transmission Systems. Dr. Louis Bell. Considers regulation the crucial point in the operation of power transmission plants for general distribution, discussing the details. 4500 w. Cassier's Mag—June, 1904. No. 63528 B.

Resistance.

The Determination of Resistances in the Conductors of Multiple-Wire Systems (Bestimenung des Isolationswiderstandes der Einzetleiter von Gleichstrom-Mehrleiter-anlagen während des Betriebes). Dr. J. Sahulka Discussing the distribution of resistances for continuous currents in multiple circuits. 3000 w. Elektrotech Zeitschr—May 26, 1904. No. 63203 B.

Rotary Concerters.

Efficiency Curves of Rotary Converters. A. S. McAllister. Come facts concerning the curves of rotary converters. 700 w. Elec Wld & Engr—June 4, 1904. No. 63109.

Sub-Station.

The Electric Installation of the Batignolles Freight Station of the Western Railway of France (Installations Electriques de la Compagnie de l'Ouest à la Gare de Batignolles-Marchandises). M. Soubrier. Describing a transformer substation, with details of switchboards and distribution. Serial. 1st part. 3000 w. Revue Tech—May 25, 1904. No. 63233 D.

Wiring.

The Continuous Protection of Conductors. Briefly reviews the wiring systems in general use, considering their advantages, and describes screwed stud fittings. Ills. 1100 w. Elec Rev, Lond—June 10, 1904. No. 63431 A.

ELECTRO-CHEMISTRY.

Batteries.

Experiments with a New Primary Cell. E. George P. Bousfield. Describes experiments carried out by the writer with a cell invented by W. R. Bousfield. Short discussion. 1200 w. Elec-Chem & Met—May, 1904. No. 63336 C.

New Batteries for the Electro-chemical Laboratory (Neue Batterien für das Elektrochemische Laboratorium). E. Weichmann. Illustrating and describing a variety of primary batteries suitable for laboratory research. 2000 w. Elektrochemische Zeitschr—June, 1904. No. 63281 D.

Cadmium Cell.

Report of the Committee on the Cadmium Cell. Preliminary report of the committee appointed to report on the preparation of materials and the construction of the cadmium or Weston cell. 2500 w. Trans Am Inst of Elec Engrs—May 17, 1904. No. 63350 D.

Convention.

The Bonn Meeting of the German So-

We supply copies of these articles. See page 878.

ciety of Electro-Chemists. Gives abstracts of the most interesting papers. 2500 w. Engr, Lond—June 10, 1904. No. 63440 A.

Smelting.

Electric Smelting in Europe. From the *Canadian Manufacturer*. Principal facts in the report of the commission sent to Europe to investigate electric smelting processes. Describes experiments with the Keller furnace. 1500 w. Ir Age—June 16, 1904. No. 63378.

The Electric Furnace for Iron and Steel. P. McK. Bennie. Abstract of a paper read before the Found. Assn. at Philadelphia. Alludes to the limitations of the electric furnace, considering the progress made in Europe in its application to iron and steel production, the classes of electric reduction, and of electric furnaces describing the Keller process. 3500 w. Ir Trd Rev—June 16, 1904. No. 63400.

The Electrothermic Production of Iron and Steel. Alfred Stansfield. Discusses the commercial possibility of producing iron and steel in the electric furnace, reviewing the attempts that have been made, the cost, &c. 4000 w. Can Soc of Civ Engrs, Adv Proof—March 1904. No. 63327 D.

Storage Batteries.

Storage Battery Plate Construction. S. H. Rabenalt. Discussing the precautions to be observed to obtain the best results from batteries of the Planté type. 2500 w. Elec Wld & Engr—June 18, 1904. No. 63465.

ELETRO-PHYSICS.

Induction Coils.

Induction Coil Design. Mortimer A. Codd. Discusses points in design which affect the efficiency. 1500 w. Elec Rev, Lond—May 20, 1904. Serial. 1st part. No. 63009 A.

Radio Activity.

The Properties and Changes in the Emanation from Radium (Emanation du Radium, ses Propriétes et ses Changements). Sir William Ramsay. An authoritative account of the experiment, showing the change of radium emanation into helium. 3500 w. Comptes Rendus—June 6, 1904. No. 63258 D.

The Radio-activity of Gases Disengaged from Waters of Mineral Springs (Sur la Radio-activité des Gaz qui se Dégagent de l'Eau des Sources Thermales). P. Curie and A. Laborde. Giving results of tests from a number of springs, showing a perceptible and variable amount of radio activity. 1500 w. Comptes Rendus—May 9, 1904. No. 63250 D.

Spark Potentials.

Conditions which Influence Spark Potential Values. E. A. Ekern. Gives facts proving that the spark potential for a given gap and pressure is a variable quantity, depending on the shape of the electrodes and the proximity of solid dielectrics to the electrodes. Ills. 1600 w. Sib Jour of Engng—June, 1904. No. 63392 C.

Thermo-Electricity.

Thermo-Electric Researches (Ueber Thermoelektrische Versuche). Dr. C. Déguisne. A study of the production of electric currents in a single wire by a moving source of heat. 1200 w. Elektrotech Zeitschr—May 26, 1904. No. 63204 B.

Waves.

Alternating-Current Wave Form Analysis. S. M. Kintner. Gives details of one of the methods of harmonic analysis, discussing the theory and giving such instructions as are needed to carry out the analysis. 2500 w. Elec Wld & Engr—May 28, 1904. No. 63033.

On a New Standard of Wave-length. Dr. James E. Ives. Illustrates and describes the apparatus used, and the method. Also editorial. 3000 w. Elec Wld & Engr—June 4, 1904. No. 63108.

Wave Form Variations of a Long-Distance Line. George H. Rowe. Gives a map showing the lines of the Standard Electric Co.'s system, in which the oscillographic curves were taken, describes the instrument and method of testing, and gives a summary of conclusions for consideration. 2200 w. Trans Am Inst of Elect Engrs—May 17, 1904. No. 63346 D.

GENERATING STATIONS.

Alternators.

The Pressure Drop in Alternating Generators (Ueber den Spannungsabfall in Wechselstromgeneratoren). Dr. H. Behn-Eschenburg. Discussing the mathematical method of computing the drop in voltage for a proposed machine. 4000 w. Elektrotech Zeitschr—May 19, 1904. No. 63200 B.

British Stations.

Some British Central Electric Power Stations. H. F. Parshall. Brief illustrated descriptions of the more important stations designed by the writer, representing modern practice in Great Britain. 3000 w. Cassier's Mag—June, 1904. No. 63533 B.

Brushes.

Why Use Carbon Brushes on the Modern Dynamos? J. W. Burleigh. Discusses the substitution of metal for carbon brushes, giving some designs. Ills. 700 w. Elec Rev, Lond—June 10, 1904. No. 63432 A.

Cape Town.

Cape Town Corporation Electricity

We supply copies of these articles. See page 878.

Works. Information concerning the new electricity works recently opened. Ills. 3200 w. Electn, Lond—May 27, 1904. Serial. 1st part. No. 63118 A.

Dynamos.

Compensating and Compound Windings for Continuous--Current Dynamos (Kompensierende und Compoundierende Wendepolwickelungen für Gleichstrommaschinen). J. Seidener. Discussing the methods of reducing sparking by compensating winding. 1800 w. Zeitschr f Elektrotechnik—June 12, 1904. No. 63268 D.

High Potentials.

The Advisability and Methods of Grounding the Neutral on High Potential Alternating-Current Generators. George N. Eastman. Read before the Nat. Elec. Lgt. Assn. Presents conditions resulting in a production of dangerous potentials relative to earth, showing these conditions will only arise in a system which is insulated from the earth. 2800 w. Elec Rev, N. Y.—June 11, 1904. No. 63181.

Humming.

The Humming of Dynamos (Ueber das Pfeifen von Maschinen). J. Fischer-Hinnen. A discussion of the causes of the humming noise emitted by dynamos, and its alleviation. 1500 w. Zeitschr f Elektrotechnik—June 5, 1904. No. 63266 D.

Hydro-Electric.

Electric Power from Shawinigan Falls, Canada. Wallace C. Johnson. Gives an illustrated description of the hydraulic development. 4000 w. Cassier's Mag—June, 1904. No. 63529 B.

Electric Power from Shawinigan Falls, Canada. Ralph D. Mershon. An illustrated detailed description of the electric transmission plant. 3500 w. Cassier's Mag—June, 1904. No. 63530 B.

The Garvin's Falls Dam and Canal. Illustrated detailed description of the plant under construction for the Manchester Traction, Light and Power Co., in New Hampshire. 3000 w. Eng Rec—May 28, 1904. No. 63044.

The Hydro-Electric Station at Kykkelsrud, Norway (Usine Hydro-Electrique de Kykkelsrud). With plan of buildings and details of turbines for the development of 12,000 horse-power. There are 44,000 h. p. available. 1800 w. 1 plate. Génié Civil—May 21, 1904. No. 63227 D.

The Largest Electric Water Power Station in New Hampshire. An illustrated article giving facts of interest relating to the development at Garvin's Falls, which furnishes light and power for Manchester. 3800 w. Elec Wld & Engr—May 28, 1904. Serial. 1st part. No. 63030.

Isolated Plant.

Power Plant of the Whitlock Branch of the American Cigar Company, Richmond, Va. Illustrated description of a plant driven by means of alternating-current motors, chiefly interesting from the standpoint of its design. 1700 w. Eng Rec—June 11, 1904. No. 63190.

Parallel Driving.

The Requirements Upon Motors for the Parallel-Driving of Alternators (Anforderungen an Antriebmotoren beim Parallel betrieb von Wechselstrom-dynamos). E. Rosenberg. Discussing especially matters of speed-regulation. Two articles. 8000 w. Zeitschr d Ver Deutscher Ing—May 28, June 4, 1904. No. 63215 each D.

Paris.

A Large, Modern Paris Generating Plant. C. L. Durand. Illustrated description of a large plant recently erected by the Compagnie Parisienne de l'Air Comprimé. 3000 w. Elec Rev, N. Y.—May 28, 1904. No. 63025.

Sparking.

Predetermination of Sparking in Direct-Current Machines. W. L. Waters. Considers the most important conditions which effect the sparking, deducing a formula that will give fairly accurate results when applied to machines similarly designed, and some idea when applied to different designs. 3000 w. Trans Am Inst of Elec Engrs—May 17, 1904. No. 63344 D.

Switzerland.

The New Electric Works at Neuchatel, Switzerland. A. Steere. Illustrated description of an interesting installation. 1600 w. Eng Rec—June 4, 1904. No. 63099.

Utah.

Bear River Power Plant and Utah Transmission Systems. Illustrates and describes a plant which utilizes the surplus water of an irrigation system during the season of high water. 1500 w. Elec Wld & Engr—June 18, 1904. Serial. 1st part. No. 63462.

LIGHTING.

Arcs.

Alternating Current Arc Systems. Richard Fleming. Illustrates and describes appliances used and the lamps of various types. 2000 w. Engr, U S A—June 1, 1904. No 62092 C.

Arc Light Photometry. C. P. Matthews. Describes two different equipments for simple or semidirectional arc-light photometry. Ills. 2500 w. Engr, U S A—June 1, 1904. No. 63094 C.

Series Alternating Current Arc Lighting Plant in the Union Stock Yards. Il-

lustrates and describes the largest series enclosed arc lighting system installed in Chicago. 2200 w. Engr, U S A—June 1, 1904. No. 63091 C.

Car Lighting.

Power Required for the Electric Lighting of Passenger Carriages on the Stone System. Mr. Staby in *Zeitung des Vereins.* Information on the amount of energy consumed. 1200 w. Bul Int Ry Cong—May, 1904. No. 63124 E.

The Boehm System of Electric Lighting for Trains. The system obtains its current from a generator driven by one of the axles of the train. Its chief interest lies in the method employed to regulate the speed and voltage of the generator. Ills. 900 w. Elec Rev, Lond—June 17, 1904. No. 63541 A.

Illumination.

Electricity and Light, Charles Proteus Steinmetz. Discusses the advance being made in electric lighting, explaining the action of the incandescent lamp, the gases and vapors that are made luminous, the mercury arc, and the magnetite arc lamp. 2800 w. Cassier's Mag—June, 1904. No. 63531 B.

Mills.

The Electric Lighting of Weaving Sheds and Spinning Mills. Discusses the subject in regard to England, giving facts in the inspector's report. 1400 w. Prac Engr—May 27, 1904. Serial. 1st part. No. 63040 A.

New England.

Rise of Electric Lighting in New England. Alton D. Adams. A concise review of the early history. 1500 w. Elec Wld & Engr—May 28, 1904. No. 63031.

Photometry.

Candle-Power Tests of Cooper Hewitt Mercury Vapor Lamp. L. A. Freudenberger. Describes tests made at Delaware College, Newark, Del., on a vapor lamp known commercially as Type H-4. 600 w. Elec Wld & Engr—June 25, 1904. No. 63552.

Principles of Photometry. An explanation of the principles for measuring the intensity of light. Ills. 2200 w. Engr, U S A—June 1, 1904. No. 63093 C.

Rating.

The Proper Commercial Rating of Incandescent Lamps. E. Leavenworth Elliott. Points out what the writer considers the shortcomings of the present accepted method of rating, explaining the scientific principles involved. 1500 w. Cent Sta—June, 1904. No. 63304.

Three-Wire.

A Three-Wire Five-Hundred-Volt Lighting System. Walter I. Barnes. Read before the Nat. Elec. Lgt. Assn. Describes the construction work, giving an outline of the development of the Narragansett Elec. Lgt. Co. 3200 w. Elec Rev, N Y—May 28, 1904. No. 63027.

MEASUREMENT.

Diagrams.

Diagrams and Measurements for Polyphase Motors (Diagramm und Ausmessung von Drehstrommotoren). Hugo Grob. An extended study of the application of the Heyland circle diagram. Two articles. 15,000 w. Elektrotech Zeitschr—June 2, 9, 1904. No. 63207 each B.

Electrical Survey.

Method of Making Electrical Survey of Rochester, N. Y. An account of a special survey and report made by Albert R. Herrick, describing methods. Ills. 3000 w. Munic Engng—June, 1904. No. 63324 C.

Space Telegraphy.

The Telefunken Ondometer for the Measurement of Wireless Telegraphy. Illustrates and describes an apparatus for measuring wave-lengths. 900 w. Sci Am Sup—June 25, 1904. No. 63537.

Symbols.

Graphical Symbols for Elements in the Technology of Weak Currents—Einheitliche Graphische Bezeichnungen in der Schwachstromtechnik). J. Baumann. Advocating the use of certain symbols for batteries, transformers, interrupters, etc. 2500 w. Elektrotech Zeitschr—June 2, 1904. No. 63206 B.

Testing.

Data and Tests on a 10,000-Cycle-per-second Alternator. B. G. Lamme. Presents data of the machine and the tests obtained. Ills. 2200 w. Trans Am Inst of Elec Engrs—May 17, 1904. No. 63347 D.

Practical Alternating Current Testing. Charles F. Smith. Begins a study of the application of general experimental laws to the case of alternating-current machinery. 3000 w. Mech Engr—June 18, 1904. Serial. 1st part. No. 63546 A.

Test of a Direct-Current Dynamo by the Schüttorf Machine Works. (Prüfung einer Gleichstrom Dynamomaschineder Schüttorfer Maschinenfabrik). W. Winkelmann. With detailed illustrations of the machine and data and results of test. 1500 w. Elektrotech Zeitschr—May 19, 1904. No. 63201 B.

Units.

Electrotechnical Measuring Systems (Ueber Elektrotechnische Mass-systeme). Fritz Emde. Outlining a general system of physical measurements and units for

We supply copies of these articles. See page 878.

discussion at the St. Louis Electrical Congress. 10,000 w. Elektrotech Zeitschr—May 26, 1904. No. 63205 B.

Wattmeters.

An Expression for the Torque of a Polyphase Wattmeter. F. R. Stowe. Mathematical discussion. 500 w. Elec Wld & Engr—May 28, 1904. No. 63032.

MOTORS.

Induction Motors.

A Hopkinson Test for Multiphase Induction Motors. R. W. Weekes. Describes tests carried out, the method of testing, &c, giving results. 3000 w. Elec Engr, Lond—June 17 1904. No. 63543 A.

Induction Motor Design as Determined by Commercial Requirements. J. B. Wiard. Outlining the fundamental principles which govern the design, indicating the different forms which are on the market commercially. 5000 w. Jour Worcester Poly Inst—May, 1904. No. 63,317 C.

Single-Phase Commutator Motors (Ueber Einphasenkommutatormotoren). Karl Pichelmayer. A review of the various forms of single-phase motors, comparing them with the continuous-current motor. 7000 w. Elektrotech Zeitschr—June 2, 1904. No. 63209 B.

Single-Phase Motors. George T. Hanchett. A non-mathematical description of the rotative principle of the single-phase induction motor. 1500 w. Cent Sta—June, 1904. No. 63303.

The Reluctance of the Air-Gap in the Induction Motor. N. Pensabene. A study of the case of open slots in the stator and totally enclosed slots in the rotor. 900 w. Elec Engr, Lond—June 17, 1904. No. 63544 A.

The Single-Phase Induction Motor. William S. Franklin. A mathematical discussion of the design. 2700 w. Trans Am Inst of Elec Engrs—May 17, 1904. No. 63348 D.

Repulsion Motor.

The Principles of the Repulsion Motor. George T. Hanchett. A discussion of its principles of operation. Diagrams. 2000 w. St Ry Jour—May 28, 1904. No. 63029 C.

The Repulsion Motor. F. W. Carter. Discusses the principles and properties of a single-phase alternating-current motor whose speed characteristic droops considerably with increase of train resistance. 1000 w. Elec Rev, Lond—May 27, 1904. Serial. 1st part. No. 63116 A.

Self Induction.

Effect of Self-Induction on Railway Motor Commutation. E. H. Anderson. Deals with fundamental features of railway motor commutation, illustrating by oscillograph records. 2700 w. Trans Am Inst of Elec Engrs—May 17, 1904. No. 63345 D.

Synchronous Motors.

Influence of the Line on the Parallel Operation of Synchronous Motors. Abstracts of the papers by Signor Rebora and Signor Guido Jemenza, in the *Transactions* of the Italian Assn. of Elec. Engrs. Also Editorial. 4000 w. Elec Wld & Engr—June 18, 1904. No. 63463.

Synchronous Motors for Regulation of Power-Factor and Line Pressure. B. G. Lamme. Shows how a synchronous motor can be used to establish leading or lagging currents in its supply system, and as a regulator. 4500 w. Trans Am Inst of Elec Engrs—June 21, 1904. No. 63352 D.

Variation.

Variation of Motor Speed with Variable Line Voltage. J. L. Dickson. Outlines, in as simple a manner as possible, two different methods of investigating this question. 600 w. Elec Wld & Engr—June 18, 1904. No. 63464.

TRANSMISSION.

Line.

A One-Hundred Mile Transmission Line. Robert Howes. Read before the Nat Elec Lgt Assn. Briefly describes the essential features of the plant, the results obtained and difficulties encountered. 3800 w. Elec Rev, N Y—May 28, 1904. No. 63026.

Line Protection.

The Protection of High-Pressure Transmission Lines from Static Discharges. H. C. Wirt. Comments on devices now in use. 1200 w. Trans Am Inst of Elec Engrs—June 21, 1904. No. 63356 D.

Long-Distance.

Limitations of Long-Distance Electric Power Transmission. Paul M. Lincoln. Considers the commercial limits and the engineering limits. 5000 w. Cassier's Mag—June, 1904. No. 63526 B.

Long-Distance Power Transmission. Charles F. Scott. Considers its economic, and particularly its engineering aspects. 4500 w. Cassier's Mag—June, 1904. No. 63524 B.

The Development of Electric Power Transmission. Lewis Buckley Stillwell. Illustrating and describing cables, insulators, and general details of long-distance high-tension transmission. 8000 w. Cassier's Mag—June, 1904. No. 63523 B.

Long Spans.

Long Spans for Transmission Lines. F. O. Blackwell. Considers the principal causes of interruption in long-distance transmission, and the remedies to be gained by substituting steel tower con-

We supply copies of these articles. See page 878.

struction with long spans for a wooden pole line. 2800 w. Trans Am Inst of Elec Engrs—June 21, 1904. No. 63353 D.

Parallel Operation.

Conditions for Continuous Service Over Lines Operated in Parallel. M. H. Gerry, Jr. Advocates the use of multiple lines and proper appliances. 800 w. Trans Am Inst of Elec Engrs—June 21, 1904. No. 63354 D.

Spier Falls.

Hudson River Power in the General Electric Works. Describes the power transmission from Spier Falls, 30 miles distant. Ills. 2800 w. Elec Wld & Engr —June 11, 1904. No. 63197.

Transformers.

Discussion on "The Relative Fire-Risk of Oil and Air-Blast Transformers. 28,500 w. Trans Am Inst of Elec Engrs—March 25, 1904. No. 63349 D.

The Berthier Actino-Electric Transformer. Emile Guarini. An illustrated article sketching the main features of two forms of apparatus for producing electricity from light. 1500 w. Sci Am—June 18, 1904. No. 63383.

The Use of Ground Shields in Transformers. J. S. Peck. Considers the grounding of the low-pressure winding at the neutral point is a safer, more practical and cheaper method of protection. 600 w. Trans Am Inst of Elec Engrs—June 21, 1904. No. 63355 D.

Transformers for Long-Distance Transmission. J. S. Peck. An illustrated description of the modern transformer. 4000 w. Cassier's Mag—June, 1904. No. 63526 B.

MISCELLANY.

Cost.

The Cost of Electric Energy. G. L. Addenbrooke. A study of the prices at which electric supply can be furnished in England, especially considering supply from a central source. 4800 w. Engng—June 3, 1904. No. 63368 A.

Heating.

Electric Heating and Cooking (Ueber das Elektrische Heizen und Kochen). W. Krejza. With illustrations of a variety of electric stoves and heaters. Two articles. 4000 w. Zeitschr f Elektrotechnik—June 5, 12, 1904. No. 63267 each D.

Submarine Mines.

Electrically Operated Submarine Mines. Waldon Fawcett. Brief explanation of the operation of electrical mines, with remarks and illustrations. 1600 w. Elec Rev, N Y—June 11, 1904. No. 63182.

Welding.

Electric Welding Development. Elihu Thomson. Reviews applications made of the electric weld, showing its importance in the industries. Ills. 2000 w. Cassier's Mag—June, 1904. No. 63532 B.

GAS WORKS ENGINEERING

Acetylene.

Purification and Combustion of Acetylene. From *La Nature.* Explains the process proposed by Prof. Ullmann, in which "heratol" is used to purify the acetylene, and describes the burners most successful. Ills. 1200 w. Sci Am Sup—June 18, 1904. No. 63387.

Automatic Lighting.

Westenholz's Patent Automatic Gas Lighter and Extinguisher. An account of a new invention from Denmark, stating its merits and advantages. Ills. 1400 w. Jour Gas Lgt—June 7, 1904. No. 63376 A.

Benzine.

The Decomposition of Benzine at High Temperatures. G. W. McKee. Read before the Canadian Sec. of the Soc. of Chem. Ind. An account of experiments made to obtain light on the effect of transition temperatures. 1000 w. Gas Wld—May 21, 1904. No. 63001 A.

Charging.

Charging Machinery at Lyons. M. Boutan. Read before the Soc. Tech. de L' Ind. du Gaz en France. Illustrated description of the charging machinery and its working. 2500 w. Gas Wld—June 18, 1904. No. 63504 A.

Oerlikon and Bertrand Chargers and Dischargers. M. J. Thelliez. Read before the Soc. Tech. de L' Ind. du Gaz en France. An illustrated article explaining the charging and discharging movement, the lifting and lowering to different levels, &c. 900 w. Gas Wld—June 18, 1904. No. 63505 A.

Combustion.

The Mechanism of Combustion. Harold B. Dixon. Lecture before the Inst. of Gas Engrs. Reviews the theories advanced and discusses the subject in detail. Ills. 11,000 w. Gas Wld—June 11, 1904. No. 63491 A.

Comparison.

Coal Gas and Water Gas. Alton D. Adams. Discusses the relative advantages of each and the cost of manufacture as shown in plants of various capacities in Massachusetts. 1700 w. Mines and Min —June, 1904. No. 63144 C.

We supply copies of these articles. See page 878.

Condensation.

Condensation of Illuminating Gas. Dr. Harold G. Colman. Read before the Inst. of Gas Engrs. Considers chiefly what may be called the action of the condensing apparatus as a washer or scrubber for the various vapors present in the hot gases issuing from the retorts. General discussion. 9500 w. Gas Wld—June 11, 1904. No. 63492 A.

Enrichment.

Water Gas Tar Used in Generators for Enrichment. Henry I. Lea. Read before the Ohio Gas Lgt. Assn. Reports plants that have used oil tar in generators and the results, discussing its value. General discussion. 3800 w. Am Gas Lgt Jour—May 30, 1904. No. 63034.

Gas Coals.

The Analytical Valuation of Gas Coals. G. P. Lishman. Abstract of a paper submitted to the Inst. of Min. Engrs. Report of an investigation to determine the value. 2500 w. Gas Wld—June 4, 1904. No. 63364 A.

Gasholders.

Experience at Middlesbrough with Gasholder Tanks on Marshland. David Terrace. Read before the Inst. of Gas Engrs. On the difficulties and means adopted to remedy them. Ills. 2200 w. Gas Wld—June 11, 1904. No. 63490 A.

Gas Stoves.

The Gas Stove Considered from a Chemical and Sanitary Standpoint. Francis C. Phillips. Describes types at present used, and tests made where natural gas was used; discussing the effect upon health from the products of combustion. 4000 w. Pro Engrs' Soc of W Penn—Feb., 1904. No. 63388 D.

High Pressure.

Distributing Gas at 25 lbs. Pressure per Square Inch. George Helps. Reviews what has been done in America and in England with high-pressure gas, discussing the advantages and disadvantages, and describing the Nuneaton installation. 4500 w. Gas Wld—May 28, 1904. No. 63114 A.

The Flow of Gas in Mains, and Distribution at High Pressure. Read before the Inst. of Gas Engrs. by W. C. Unwin. A discussion of this subject, the difficulties, and American practice in high-pressure distribution. General discussion. Diagrams. 11000 w. Gas Wld—June 11, 1904. No. 63494 A.

Illumination.

Artificial Gas Illumination in Relation to Natural Light. William Sugg. Read before the Inst. of Gas Engrs. A study of natural light and the effect of artificial light of high power on the eye sight, with suggestions. Ills. 3200 w. Gas Wld—June 11, 1904. No. 63496 A.

Meters.

Ten Years' Experience with the Prepayment Meter. Alfred Colson. Read before the Inst. Gas Engrs. Discusses the working of the slot meter system in Leicester, Eng., giving the results obtained, the methods of collecting and inspecting, &c. Also discussion. 9000 w. Gas Wld—June 11, 1904. No. 63489 A.

New Works.

The New Works of the Hastings and St. Leonard's Gas Company. An illustrated account of the progress at Glyne Gap. 4800 w. Jour Gas Lgt—May 31, 1904. No. 63358 A.

Operation.

The Granton Gas Works of the Edinburgh and Leith Gas Commissioners. Analysis of the manufacturing costs and charges for the year ending May 15. 1904. 1600 w. Jour Gas Lgt—May 31, 1904. No. 63357 A.

Photometry.

The Photometrical Valuation of Gas. H. Leicester Greville. Remarks on how photometry as a science can best be combined with gas testing. 1700 w. Jour Gas Lgt—May 24, 1904. No. 63039 A.

Small Coal.

The Uses of Small Coal. Remarks on the influence of washeries on the coal industry, with reference to a paper by Mr. Mackey, read before the Soc. of Chem. Ind. 1900 w. Jour Gas Lgt—May 24, 1904. No. 63038 A.

Stoking Machinery.

De Brouwer Stoking Machinery at Derby. J. Ferguson Bell. Read before the Inst. of Gas Engrs. An illustrated description of the plant, with results obtained by continuous working during the past eight months. General discussion. 11800 w. Gas Wld—June 11, 1904. No. 63493 A.

INDUSTRIAL ECONOMY

Apprentices.

Apprentices in the Foundry. O. P. Briggs. Read before the New England Found. Assn. Discusses the character and qualifications of the boy, the attitude of the foreman, methods of raising the standard, &c. 4000 w. Ir Trd Rev—June 23, 1904. No. 63501.

We supply copies of these articles. See page 878.

Combinations.

Rings, Combinations and Trusts (Ringe, Kartelle und Trusts). Georg Gothein. An examination of industrial combinations from the continental viewpoint. 6000 w. Zeitschr d Ver Deutscher Ing—May 28, 1904. No. 63216 D.

Competition.

Mining Royalties and the Iron Trades. Some Conditions of Foreign Competition. T. Good. Discusses conditions in England detrimental to the iron industry. 2800 w. Engng Rev—June, 1904. No. 63538 B.

Education.

The Electrotechnical Institute of the Technical High School at Vienna (Das Elektrotechnische Institut der k. k. Technischen Hochschule in Wien). Prof. Karl Hochenegg. An illustrated account of the electrical laboratory of the Vienna technical high school. 4500 w. Zeitschr d Oesterr Ing a Arch Ver—May 13, 1904. No. 63236 D.

The Technical High School at Darmstadt (Die Grossherzogliche Technische Hochschule in Darmstadt). O. Berndt. With plan of the buildings, view of the new electrical building, and an account of the growth of the school. 1200 w. Zeitschr d Ver Deutscher Ing—June 11, 1904. No. 63220 D.

The Tuition (?) of Electrical Engineering. James Pigg. Read before the Newcastle Soc. of the Inst. of Elec. Engrs. Considers some of the advantages of other methods than those in use, especially correspondence schools. 5300 w. Elec Engr, Lond—June 3, 1904. Serial. 1st part. No. 63367 A.

Efficiency.

The Conditions of Maximum Productive Efficiency. Ralph Neville. Discussing the necessity for incentive as a condition for efficient production in all departments of industry. 3500 w. Engineering Magazine, July, 1904. No. 63282 B.

Indexing.

Engineering Index and Library Work. G. W. Lee. Describes the system in use in the reference library of Stone & Webster, of Boston. Also Editorial. 2200 w. Eng News—June 16, 1904. No. 63410.

Inspection.

Inspection as a Factor in Cheap Production. Charles U. Carpenter. Discussing inspection as a necessary complement of standardized production, for the maintenance of accurate work. 3000 w. Engineering Magazine—July, 1904. No. 63289 B.

Iron Warrants.

Pig Iron Warrant System and the Foundry. George H. Hull. Read before the Am. Found. Assn. Discusses this question in connection with the proposed letting of a contract for the large amount of castings in connection with the Pennsylvania R. R. Tunnels in New York. 3300 w. Ir Trd Rev—June 23, 1904. No. 63502.

Laboratory.

A Factory Research Laboratory. Illustrated description of the laboratory in the cycle works of Messrs. Rudge-Whitworth, Ltd., an exceptionally fine example. 2200 w. Engr, Lond—June 10, 1904. Serial. 1st part. No. 63438 A.

The New Power House and Mechanical Laboratory of the Technical High School at Darmstadt (Das Neue Kraftwerk und das Neue Maschinenbaulaboratorium der Technischen Hochschule Darmstadt). Prof. M. F. Gutermuth. Describing especially the steam generating plant, and boilers, superheaters, &c. Serial. Part I. 3000 W. Zeitschr d Ver Deutscher Ing—June 11, 1904. No. 63221 D.

The Testing Laboratory of the Conservatorie des Arts et Metiers (Laboratoire d'Essais du Conservatoire des Arts et Metiers). A. Boyer-Guillon. Describing especially the department relating to the testing of automobiles, steam engines, and other machines. Two articles. 5000 w. 1 plate. Génie Civil—May 21, 28, 1904. No. 63225 each D.

Office Equipment.

Mechanical Aids in Factory Office Equipment. George Harvey Seward. With numerous illustrations of mechanical computers, slide rules, and other calculating machines adapted for office and factory use. 5000 w. Engineering Magazine—July, 1904. No. 63291 B.

Peru.

The Way into Peru. F. J. Schafer. Describes an important project for opening up one of the richest and most fertile districts of Peru, showing that improvement in transport facilities is the one thing needful, and discussing the difficulties. Ills. 2800 w. Page's Mag—June, 1904. No. 63515 B.

Premium System.

The Premium System Applied to Mining. H. Foster Bain. Considers some of the methods by which costs of mining may be reduced. 2200 w. Mines & Min—June, 1904. No. 63149 C.

Promotion.

Light Railway and Tramway Promotion Procedure. Arthur P. Poley. The first of a series of articles giving an account of the procedure and rules applicable to applications made by promoters in England. 3000 w. Tram & Ry Wld—June 9, 1904. No. 63484 B.

We supply copies of these articles. See page 878.

Railways.

Railway Economics. Editorial review of the statement of the Board of Trade on the results of the work of the railways of the United Kingdom during the past year. 1800 w. Engng—May 20, 1904. No. 63014 A.

Technology.

Law, Industry and Technology (Recht, Wirtschaft und Technik.) Dr. Herm. Beck. An address showing the relation of technology to the other elements of civilization. Two articles. 8000 w. Zeitschr—d Ver Deutscher Ing—May 14, 21, 1904. No. 63214 each D.

Wages.

Wage Systems and Their Bearing upon Output. George N. Barnes. An examination of the various forms of piece work, contract, premium, bonus and other wage systems, and their relation to the industrial position of the workman .4000 w. Engineering Magazine—July, 1904. No. 63283 B.

Works Management.

A Bibliography of Works Management. Hugo Diemer. Listing the most important books which have been written on the subject in the English language, with brief descriptive notes, followed by a comprehensive index of the current literature of the subject from 1885 to date. 15000 w. Engineering Magazine—July, 1904. No. 63292 B.

MARINE AND NAVAL ENGINEERING

Approximate Integration.

New Rules for Approximate Integration. George R. McDermott. Gives a résumé of results of a study of existent rules for various spacings of ordinates, and explains a rule independently derived for the solution of a stated problem. 1500 w. Sib Jour of Engng—June, 1904. No. 63391 C.

Battleships.

The Tendency of Battleship Design. Discusses recent changes and the characteristics of a proposed battleship to meet present conditions. 1600 w. Engr, Lond—June 10, 1904. No. 63436 A.

The United States Battleship Virginia. Illustrations, plans and detailed descriptions of this recently launched vessel. 3000 w. Marine Engng—June, 1904. No. 62985 C.

Cable Steamer.

The Cable Steamer "Pacific." Illustrated detailed description of the latest built ship of this class. 3000 w. Electn, Lond—May 20, 1904. No. 63010 A.

Electrical Apparatus.

Electricity in the British Naval and Merchant Marine. Sydney F. Walker. Reports the progress, and describes some of the arrangements. 1600 w. Marine Engng—June, 1904. No. 62987 C.

Explosives.

The Detonation of Explosives under Water (Dètonation sous l'Eau des Substances Explosifs). M. Jacob. A study of the relation of the compressibility of the fluid to the action of the explosive. 1200 w. Comptes Rendus—May 24, 1904. No. 63253 D.

Freight Carriers.

Freight Carriers of the Great Lakes. Illustrated review of the types of vessels used on the Great Lakes at various times, especially cargo vessels, with some points in regard to their history. 3500 w. Marine Rev—June 2, 1904. No. 63087.

Recent Developments in Cargo and Intermediate Steamers. Edwin William De Rusett. An illustrated article considering the type, size, construction, capacity, cargo appliances, and economy of working, showing the great progress made during the five years. 5000 w. Marine Rev—June 2, 1904. No. 63086.

The Development of the Freight Carrier in the Atlantic Coastwise Trade. Ray Morris. An illustrated article discussing the development of coastwise freight traffic. 4000 w. Marine Rev—June 2, 1904. No. 63085.

Gunboat.

H. M. Gunboat Widgeon. Illustrated description of a twin-screw shallow-draught vessel, fitted with Yarrow's patent movable flap. 900 w. Engr, Lond—May 27, 1904. No. 63136 A.

Light Outfits.

Electric Lighting Outfit for Launches. D. A. Richardson. An illustrated article discussing the requirements. 1500 w. Marine Engng—June, 1904. No. 62986 C.

Rolling.

On the Heeling and Rolling of Ships of Small Initial Stability. A. Scribanti. Investigations of the influence which a varying amount of initial stability can exert on some mechanical features of a given ship. 2800 w. Engng—May 27, 1904. Serial. 1st part. No. 63130 A.

Salvage.

Marine Salvage and Wreck Raising. Describes the equipment of the salvage

We supply copies of these articles. See page 878.

vessel Ranger, and some information of the work. 1500 w. Engr, Lond—May 27, 1904. No. 63135 A.

Steamboats.

Hudson River Steamboats. An illustrated article, especially describing the latest addition to this fleet—the C. W. Morse, a million-dollar craft for the People's Line. 4500 w. Naut Gaz—June 2, 1904. No. 63151.

Steamboat C. W. Morse, for the Hudson River. Illustrated description of a large side-wheel steamboat for the People's line between New York and Albany. 1800 w. Marine Engng—June, 1904. No. 62989 C.

Steam Navigation.

Progress of Steam Navigation. Robert Caird. Presented before the Royal Philosophical Soc., Glasgow. A review of the progress from 1802 to 1902. The present article considers mainly British merchant shipping of the largest size. 4500 w. Naut Gaz—June 16, 1904. Serial. 1st part. No. 63396.

Tug Boat.

Shallow-Draft, Twin-Screw Tug Boat for the Northwest. Illustrated description of a boat intended for use in towing logs on the Saskatchewan River. 400 w. Marine Engng—June, 1904. 62988 C.

MECHANICAL ENGINEERING

AUTOMOBILES.

Accumulators.

Notes on Recharging Accumulators. On the mistake of charging a 4-volt accumulator with 5 or 6 volts at the terminals. 900 w. Motor Car Jour—June 18, 1904. No. 63540 A.

Car Houses.

Motor car houses. B. Wyand. Suggestions for erecting buildings suitable for small and large vehicles. Ills. 900 w. Autocar—June 18, 1904. No. 63550 A.

Commercial Vehicles.

Recent English and French Merchandise and Passenger Wagons (Neuere Englische und Französische Motorwagen für Personen und Güter). A. Heller. Illustrating recent trucks, surries, fire-engines and commercial vehicles. Serial. Part I. 3000 w. Zeitschr d Ver Deutscher Ing—June 4, 1904. No. 63219 D.

The Automobile in Business. J. A. Kingman. Considers these vehicles as used in New York City; the cost and the expense of running, and the general operation. Ills. 3800 w. Rev of Revs—June, 1904. No. 63309 C.

Petrol Car.

The "Ford" Petrol Car. Illustrated detailed description of a light car built in Detroit. 1800 w. Auto Jour—June 11, 1904. Serial. 1st part. No. 63426 A.

The 1904 Clement Petrol Cars. Illustrated description of these cars, built in Paris. 1200 w. Auto Jour—May 28, 1904. Serial. 1st part. No. 63112 A.

Racer.

The Six-Cylinder Napier Racer. Brief Illustrated description. 800 w. Auto Jour—June 18, 1904. No. 63549 A.

Radiators.

Experiments Showing the Efficiency of Radiators for Gasoline Automobiles. Gives results of tests made under the supervision of William S. Conant and Benjamin Briscoe. 3500 w. Sci Am Sup—June 11, 1904. No. 63307.

Speed Gears.

The Balance Gear Explained. Hurbert C. Clarke. An illustrated description of the balance or differential gear. 2000 w. Autocar—June 4, 1904. No. 63361 A.

The Columbia Bicycle Two-Speed Gear. Illustrated description of a combined freewheel, brake and speed-changing mechanism. 1700 w. Mach, N. Y.—June, 1904. No. 63065 C.

The 8 H.-P. De Dion Three-Speed Gear. Illustrated detailed description. 1300 w. Autocar—June 11, 1904. No. 63428 A.

Steam Car.

The Turner-Miesse Steam Car. Illustrated detailed description. 1200 w. Motor Car Jour—May 28, 1904. Serial. 1st part. No. 63095 A.

Sutton Engine.

The Sutton "Heavy" Oil Engine. An illustrated detailed description of the Sutton system and its use on motor cars. 3300 w. Auto Jour—June 4, 1904. No. 63360 A.

Tires.

Non-Skidding Tires and Protective Bands for Use on the Wheels of Automobiles. Illustrates and describes types tried in the tests in France, giving points determined by the tests. 800 w. Sci Am—June 25, 1904. No. 63535.

Trials.

The Gordon-Bennett French Eliminating Trials. An illustrated account of the trials to find out the best drivers and cars. 3000 w. Auto Jour—May 21, 1904. No. 63000 A.

We supply copies of these articles. See page 878.

The Gordon-Bennet French Eliminating Trials. An illustrated accounts of trials in France. 1800 w. Auto Jour—May 28, 1904. No. 63111 A.

See also Mechanical Engineering. Internal Combustion Motors.

HEATING AND COOLING.

Hot Water.

Description of Hot Water Heating Apparatus in the Schioldann Institution, Copenhagen, Denmark. A. B. Beck. Read before the Am. Soc. of Heat. & Ven. Engrs. Ills. 4500 w. Dom Engng—May 25, 1904. No. 63019 C.

Refrigeration.

The Ammonia Condenser. T. R. Wingrove. Discusses the various conditions which affect the circulation of the ammonia. Diagram. 1800 w. Ice & Refrig—June, 1904. No. 63069 C.

The Production and Applications of Artificial Cold (Production et Application du Froid Artificiel). F. Cottarel. A study of artificial refrigeration, with descriptions of some inportant installations. Four articles. 9000 w. 3 plates. Génie Civil—May 21, 28, June 4, 11, 1904. No. 63226 each D.

Ventilation.

Notes on the Plenum System of Ventilation. W. Herrman. Introducing a discussion before the Royal Institute of British Architects. 4600 w. Archt, Lond—June 10, 1904. No. 63425 A.

HYDRAULICS.

Air-Lift.

River Wells and the Horizontal Delivery of Water. G. C. H. Friederick. Calls attention to results obtained by the air-lift system of raising water. 1500 w. Engr, U S A—June 15, 1904. No. 63403 C.

Centrifugal Pumps.

Centrifugal Pump Tests. Report of a series of exhaustive tests made by Professors William Kent and J. E. Denton, at the works of the De Laval Steam Turbine Co., Trenton, N. J., upon some of the smaller sizes of their principal types of centrifugal pumps. 3000 w. Ills. Jour Am Soc of Nav Engrs—May, 1904. No. 63468 H.

Some Tests of High-Speed Centrifugal Pumps. Condensed report of three tests made of different types of De Laval pumps. 3000 w. Eng News—June 2, 1904. No. 63079.

Hydraulic Stations.

The Proposed Law for Hydraulic Stations (Project de Loi pour les Usines Hydrauliques). An abstract of the regulations proposed for the utilization of watercourses in France. 2500 w. Revue Technique—June 10, 1904. No. 63234 D.

Pump.

Boiler-Makers' Hydraulic Machinery. The present article gives an illustrated description of pumps, the type shown being a set of three-throw horizontal belt-driven pumps. 1400 w. Prac Engr—June 2, 1904. Serial. 1st part. No. 63362 A.

Pumping.

Deep-Well Pumping Machinery. W. Percy Guarani. Read before the Graduate's Sec. of the Inst. of Mech. Engrs. Considers the rotative and non-rotative engines used for deep-well pumping. Ills. 4000 w. Mech Engr—June 18, 1904. No. 63547 A.

INTERNAL-COMBUSTION MOTORS.

Benzol.

The Value of Benzol as a Motor Fuel. A report of investigations made, giving results. 4000 w. Autocar—May 21, 1904. No. 63004 A.

Diesel.

Internal Combustion Engines and the Diesel Principle. W. H. Booth. A study of the system of compression in the Diesel engine, showing its advantages. 1000 w. Elec Rev, Lond—June 10, 1904. No. 63433 A.

Fire Engines.

The Application of Petrol Motors to Fire-Engines. Illustrates the application to a fire-boat, and also to a motor-driven land engine, with descriptions. 1300 w. Engng—May 20, 1904. No. 63013 A.

Gas Engines.

The Steam Engine as a Competitor with the Gas Engine (Die Dampfmaschine im Wettbewerb mit der Gasmachine). M. E. Captaine. Showing the relative efficiencies at various loads and speeds. 3500 w. Zeitschr d Ver Deutscher Ing—May 28, 1904. No. 63218 D.

Oil Engines.

20-Horse-Power Diagonal Oil Engines for Launch. Illustrated description. 800 w. Engng—June 3, 1904. No. 63370 A.

Petrol Engine.

The Burchall Double-Acting Petrol Engine. Illustrates and describes an ingenious construction which apparently overcomes many of the disadvantages of the double-acting engines of the ordinary type. 3000 w. Auto Jour—May 28, 1904. No. 63113 A.

Rotary Valve.

A Rotary Induction and Exhaust Valve for Explosion Engines. Illustrates and describes a balanced rotary valve, introduced by Edward Butler, London, which controls both the functions of induction and exhaust of the gases to and from the motor. 1000 w. Sci Am Sup—June 18, 1904. No. 63386.

We supply copies of these articles. See page 878.

MACHINE WORKS AND FOUNDRIES.

Annealing.

Powdered Coal for Steel Annealing. H. J. Travis. Describes the pulverizing apparatus and gives the results of observations and tests of an annealing furnace using pulverized coal as fuel. Ills. 900 w. Am Mach—June 16, 1904. No. 63380.

Borings.

The Use of Cast-Iron Borings. A. E. Outerbridge, Jr. Facts from the writer's experience concerning the smelting of cast-iron borings. 1300 w. Foundry—June, 1904. No. 63321.

Comparison.

The Law of Comparison in Engineering Structures. W. F. Durand. Describes the method used in investigating the relation between the characteristic dimensions and the output of operation, illustrating by examples. 4000 w. Sib Jour of Engng—June, 1904. No. 63390 C.

Core Bench.

The Core Bench. Benjamin D. Fuller. Read before the Am. Found. Assn. Discusses the management of the core bench. 800 w. Ir Trd Rev—June 9, 1904. No. 63163.

Cranes.

Some examples of Present Practice in Cranes and Lifting Machinery. Edward C. R. Marks. An illustrated description of various types. 1200 w. Prac Engr—May 20, 1904. Serial. 1st part. No. 63005 A.

Travelling Shipyard Crane at Vulcan Works, Bredon, Stettin. Illustrated description of an electric crane of great size designed for transporting armor plates and other heavy parts from the rolling-mill to the ships. 600 w. Engng—May 20, 1904. No. 63012 A.

Cutter Grinder.

The Becker-Brainard No. 1 14-inch Cutter and Reamer Grinder. Illustrates and describes a new machine able to handle various styles and sizes. 900 w. Ir Age—June 30, 1904. No. 63582.

Dividing Table.

A Large Dividing Table. H. G. Knoderer. Illustrated description. 1200 w. Amer Mach—June 23, 1904. No. 63507.

Drafting.

The Drafting Department as a Factor in Economical Shop Management. L. D. Burlingame. With numerous illustrations of the drafting rooms of important works and a discussion of the conditions of efficient operation. 3000 w. Engineering Magazine—July, 1904. No. 63290 B.

Drafting Instrument.

The Eccentrolinead. M. S. Smith. Illustrated description of this instrument, showing its usefulness. 800 w. Mach, N. Y.—June, 1904. No. 63067 C.

Electric Driving.

Electric Power in Manufacturing Plants. Dugald C. and William B. Jackson. An illustrated article discussing points to be considered in determining the most economical and satisfactory means of distributing and applying the power. 5700 w. Cassier's Mag—June, 1904. No. 63527 B.

Expanding.

Modern Expanding and Flanging Machinery and Tools—Luther D. Lovekin. Illustrates and describes machinery for expanding pipe into flanges. 2000 w. Jour Fr Inst—June, 1904. Serial. 1st part. No. 63341 D.

Fan Blowers.

Cupola Fan Practice. W. H. Carrier. Abstract of paper read before the Am. Found. Assn. Gives data relative to the operation of centrifugal blowers for cupola service, including the air supply required per pound of coke used and per ton of iron produced, etc. 3500 w. Ir Age - June 23, 1904. No. 63474.

Forming Tools.

Straight and Circular Forming Tools. Joseph M. Stabel. Illustrated description of the straight and circular forming tools used on screw machines. 2200 w. Mach, N. Y.—June, 1004. No. 63063 C.

Foundries.

Some Types of Modern Foundries. Illustrates and describes three modern foundries recently visited in the United States. 2000 w. Ir & Coal Trades Rev—June 17, 1904. No. 63500 A.

The Electrical Equipment of a Modern Type Foundry. Illustrated description of the plant of the American Type Founders' Company, Jersey City, N. J. 3500 w. Elec Rev, N. Y.—June 25, 1904. No. 63506.

Foundry Appliances.

Labor Saving Suggestions for the Foundry. H. F. Frohman. Read before the Am. Foun. Assn. Describes minor articles generally overlooked. 1200 w. Ir Trd Rev—June 9, 1904. No .63162.

Gear Cutters.

The Flather Gear Cutter. Illustrates and describes a new line of gear cutters, designed for the rapid production of spur gears. 900 w. Ir Age—June 30, 1904. No. 63583.

Gear Planer.

The Gleason 15-inch Shearing Cut Bevel Gear Planer. Illustrations, with detailed description. 800 w. Ir Age—June 23, 1904. No. 63471.

Green Sand.

Standard Methods for Green Sand

We supply copies of these articles. See page 878.

Beds. Thomas D. West. Read before the Am. Found. Assn. Discusses leveling straight edges to make a bed, making soft beds, method of testing the hardness of beds, how to designate kinds of beds, making hard beds and semi-hard beds for prickered plates. 6000 w. Ir Trd Rev—June 16, 1904. No. 63397.

Grinding.

A Talk on the Disk Grinder. F. N. Gardner. Considers the disk grinder with special reference to tool room work. 3500 w. Mach, N. Y.—June, 1904. No. 63,068 C.

The Grinding Machine as a Metal-Cutting Tool. C. H. Norton. An examination of the recent development of the grinding machine for sizing cylindrical parts, with illustrations of machines and products. 2500 w. Engineering Magazine—July, 1904. No. 63287 B.

Inspection.

See Industrial Economy.

Lathes.

Lathe Building Methods Used at the Works of the Lodge & Shipley Machine Tool Company. C. F. Pease. An illustrated article describing heavy casting cleaning, erecting department appliances, and stock boxes. 600 w. Am Mach—June 23, 1904. No. 63508.

Testing a Lathe. Oscar E. Perrigo. Considers particularly the inspection of the ordinary screw-cutting engine lathe, giving such description and illustrations of the necessary apparatus and methods as will insure the degree of accuracy demanded. 2000 w. Am Mach—June 2, 1904. No. 63055.

Machine Driving.

Power Transmission in Works. W. E. Buck. A discussion of the respective merits of electrical and mechanical methods for transmitting power to the machines. Two articles. 4000 w. Engr, Lond—June 3, 10, 1904. No. 63375 A.

Metal Cutting.

Advanced Practice in Economical Metal Cutting. Charles Day. A discussion of the relation of the high-speed steels to the machine tools in which they are used, showing the necessity for a consideration of all the details of the subject. 5000 w. Engineering Magazine—July, 1904. No. 63286 B.

The New Taylor-Newbold Metal Cutting Saw. Describes tests made at Philadelphia. Ills. 1200 w. Am Mach—June 16, 1904. No. 63381.

Milling Machine.

Fly-Wheel Milling Machine. Illustrates and describes a machine having features of special interest involving the discovery of a novel principle in the use of large face cutters. 1600 w. Engr, Lond—June 3, 1904. No. 63374 A.

Molding.

Crush of the Mold. William Leary. Considers the causes and remedies. 1000 w. Foundry—June, 1904. No. 63320.

Molding Machines. George C. Neilsen. From a paper before the Chicago Foundry Foremen's Assn. On the advantages and economy of these machines. 1400 w. Am Mach—June 9, 1904. No. 63171.

Molding Machines and and Their Use. E. H. Mumford. Read before the Am. Found. Assn. Calls attention to a few of these machines, with general remarks on their use. 1500 w. Ir Trd Rev—June 16, 1904. No. 63398.

Patterns.

Pattern-Making in Relation to Foundry Costs. W. H. Parry. Read before the Am. Found. Assn. Discusses the methods in use and their shortcomings. 1100 w. Ir Trd Rev—June 23, 1904. No. 63503.

Planing Machine.

New 60-inch Portable Rotary Planing Machine. Emile Guarini. Brief description, with illustration, of an interesting machine manufactured in Philadelphia. 300 w. Prac Engr—June 10, 1904. No. 63429 A.

Pneumatic Tools.

Compressed Air and Pneumatic Tools in Railroad Service. Thomas Aldcorn. Suggestions for the care of tools, discussing the uses to which they are applied, the troubles met with, etc. General discussion follows. 8000 w. Pro Cent Ry Club—May 13, 1904. No. 63584 C.

Scrap Iron.

Scrap Iron Specifications. W. G. Scott. Read before the Am. Found. Assn. Gives a general classification of the material known as "foreign scrap," which in many cases is purchased by specification. 5000 w. Ir Trd Rev—June 16, 1904. No. 63399.

Screw Machine.

Automatic Screw Machine. Illustrated description of a recent design. 1000 w. Am Mach—June 23, 1904. No. 63509.

Screw-Threads.

A Screw-Thread Angle Table. George L. Colburn. A table giving the angle of helixes of various pitches and diameters with respect to a line perpendicular to the axis, with explanatory notes. 500 w. Am Mach—June 9, 1904. No. 63173.

Shafts.

A Great Feat in Shaft Straightening. Describes the method used in straightening the tail shaft of the "Illinois." Ills. 800 w. Am Mach—June 2, 1904. No. 63054.

We supply copies of these articles. See page 878.

Sheet Metal.

Forming Sheet Metal Parts, Using Water as a Medium. Wartard Stark. Describing the use of water as a medium for forcing the metal into the die of a drop press. 700 w. Am Mach—June 30, 1904. No. 63580.

Shop Design.

Works Design as a Factor in Manufacturing Economy. Henry Hess. A study of machine shop arrangement, based upon an actual example and illustrated with views of many important establishments in Europe and America. 4500 w. Engineering Magazine—July, 1904. No. 63284 B.

Shops.

The Gutehoffnungs Works at Oberhausen (Die Gutehoffnungshütte bei Oberhausen). B. Osann. An historical and descriptive account of this famous works. Two articles. 9,000 w. 3 plates. Stahl u Eisen—April 15, May 1, 1904. No. 63269 each D.

The New Structural and Car Shops of the Cambria Steel Company, Johnstown, Pa. History of the plant, with illustrated detailed description. 4200 w. Eng Rec—June 18, 1904. Serial. 1st part. No. 63-418.

The Shops of the Jones & Lamson Machine Company. Illustrates and describes the new building and the present arrangement of this plant for building turret lathes; located at Springfield, Vermont. 3000 w. Am. Mach. June 2, 1904. No. 63053.

The Witton and Holford Works of Kynoch, Limited. Illustrated description of works for the manufacture of cartridges and ammunition, and the trades bearing upon this industry. 5000 w. Engng —May 20, 1904. No. 63011 A.

Spindles.

Spindle Construction. Howard P. Fairfield. A detailed discussion of modern methods of making spindles for drill presses and other machine tools. Ills. 2200 w. Mach, N Y—June 1904. Serial. 1st part. No. 63064 C.

Tool Rooms.

The Tool Room and Its Functions in Cost Reduction. John Ashford. An exhaustive study of the equipment and functions of the modern tool room of the well-arranged machine shop, with numerous illustrations of rooms and tools. Serial. Part I. 4500 w. Engineering Magazine —July, 1904. No. 63285 B.

Tools.

Comments on Drives for High-Speed Cutting Tools. C. E. Coolidge. Remarks on modern tools, giving calculation of cutting force on tool and speed of belt. 1700 w. Mach, N Y—June, 1904. No. 63061 C.

Turret Lathes.

Some Points in Connection with the Manufacture of a Turret Lathe—The Use of Compressed Air in Jigs and Fixtures. An illustrated article describing interesting appliances designed for use in the manufacture of turret lathes. 2500 w. Am Mach—June 16, 1904. No. 63379.

The Flat Turret Lathe with Cross Feeding Head. An article showing something of the mechanism by which the spindle and chuck are driven, the head and carriage fed, and the unique movements in general made possible. Ills. 3400 w. Am Mach—June 30, 1904. No. 63578.

MATERIALS OF CONSTRUCTION.

Alloys.

Alloys of Copper and Arsenic. Arthur H. Hiorns. Discussion of this paper before the Faraday Society. 1200 w. Elec-Chem & Met—May, 1904. No. 63337 C.

Appendix IV. to Sixth Report of the Alloys Research Committee. Dr. William Campbell. A summary of various papers by Sir William Roberts-Austin on the effects of strain and of annealing in aluminum, antimony, bismuth, cadmium, copper, lead, silver, tin and zinc. 8000 w. Ills. Trans Am Soc of Mech Engrs. No. 041—June, 1904. No. 62992 C.

Brass.

The Influence of Heat upon the Strength of Durana Metal (Warmzerreissversuche mit Durana Gussmetall). Prof. R. Stribeck. Data and results of tests upon an alloy of copper, zinc, tin and lead, showing the loss of strength with increased temperature. 3000 w. Zeitschr d Ver Deutscher Ing—June 11, 1904. No. 63224 D.

Brittleness.

A Proposed Test for Detecting Brittleness in Structural Steel. J. P. Snow. Read before the Am. Soc. for Test, Materials. Proposes a nicked bending test on crop ends of plates and shapes as they are trimmed at the rolling-mill for shipment. 2500 w. Ir Age—June 23, 1904. No. 63479.

Carborundum.

Carborundum: Its Manufacture and Uses. R. N. Kofoid. Reviews the history of the discovery, describes the manufacture and some of the uses to which it has been applied. 5700 w. Technograph, No. 18, 1903-4. No. 63311 D.

Cast Iron.

Cast Iron, Strength, Composition, Specifications. W. J. Keep. Shows strengths and chemical composition graphically and gives facts based on extensive tests. 5500 w. Trans Am Soc of Mech. Engrs, No. 029—June, 1904. No. 62990 C.

We supply copies of these articles. See page 878.

The Engineer in the Foundry. R. Moldenke. Calls attention to facts about cast iron that engineers would find it well to know. 2400 w. Am Mach—June 30, 1904. No. 63581.

Corrosion.

The Behaviour of Certain Metals in Sea Water (Das Verhalten einiger Metalle im Seewasser). H. Diegel. A report of investigations upon the corrosive action of sea water upon copper, nickel and iron alloys. Two articles. 12,000 w. Stahl u Eisen—May 15, June 1, 1904. No. 63277 each D.

Corrosion of Metals. J. F. Buchanan. Reviews the relative position of the more useful metals and alloys to corrosion, considering preventives and describing some experiences in brass-founding. 2200 w. Foundry—June, 1904. No. 63519.

Metallography.

The Effects of Strain and Annealing in Aluminum, Antimony, Bismuth, Cadmium, Copper, Lead, Silver, Tin, and Zinc. Dr. William Campbell. An appendix to the 6th report to the Alloys Research Committee. Ills. by 16 plates. 7500 w. Inst of Mech Engrs—June, 1904. No. 63334 D.

Paints.

Paints Suited for Engineering Structures. Gives information concerning the composition, chemical and physical properties of paints in general use. 1700 w. Engr, Lond—May 27, 1904. Serial. 1st part. No. 63138 A.

Protection of Metal Parts. H. M. Butts. Report on the advancement that has been made in paints for the protection of metal parts, and particularly steel cars. 1500 w. Pro Cent Ry Club—May 13, 1904. No. 63585 C.

Ropes.

Ropes of Vegetable Fiber. Charles W. Comstock. Considers the various materials used, methods of manufacture and treatment, strength and durability under different conditions, &c. 3300 w. Mines & Min—June, 1904. No. 63143 C.

Sheet Steel.

The Commercial Testing of Sheet Steel for Electrical Purposes. C. E. Skinner. Read before the Am. Soc. of Test. Materials. Describes methods of testing in daily use which have been found satisfactory, and capable of giving valuable results from an investigation standpoint. Ills. 3000 w. Ir Age—June 23, 1904. No. 63472.

Specifications.

The Influence of Specifications on Commercial Products. C. B. Dudley. Address before the Am. Soc. of Test. Materials. Considers the influence of the consumer, and the various phases of the stimulating effect of specifications. 3800 w. Ir Age—June 23, 1904. No. 63478.

Steel Castings.

The Technics of Steel Castings (Stahlformguss und Stahlformgusstechnik). Bernhard Osann. A general discussion of the methods and processes of making steel castings. Serial. Part I. 3000 w. Stahl u Eisen—June 1, 1904. No. 63280 D.

Steels.

Allov Steels. William Metcalf. Read before the Am. Soc. of Test. Materials. Considers nickel steel, manganese steel, self-hardening or air hardening steel, and high-speed steel. 2000 w. Ir Age—June 23, 1904. No. 63473.

Testing.

Bending Tests of Rolled and Riveted Beams (Biegeversuche mit Gewalzten und mit Genieteten Trägern). F. Schüle. With illustrations of the Amsler-Laffon testing machine, and data and results of tests, with especial reference to the Grey beam. Two articles. 3,500 w. Schweiz Bauzeitung—May 21, 28, 1904. No. 63260 each B.

Tool Steels.

High-Speed Tool Steels. Walter Brown. Gives interesting experiences that were successful. 1500 w. Am Mach—June 2, 1904. No. 63056.

High-Speed Tool Steels. Walter Brown. Practical suggestions for their treatment. 1500 w. Mach, N Y—June, 1904. No. 63066 C.

Treatment of Crucible Cast Tool Steel, with Chemical Composition of High-Speed Steel. Richard H. Probert. Read before the Ohio Soc. of Mech., Elec. & Steam Engrs. 3200 w. Engr, U S A—June 15, 1904. Serial. 1st part. No. 63402 C.

MEASUREMENT.

Air Resistance.

A Comparison of the Resistance of the Air to Various Forms of Balloons (Comparaison des Résistances Directes de Diverse Carènes Aeriennes). Ch. Renard. An application of the author's dynamometer to the determination of the coefficients of atmospheric resistance. The law of the square of the velocity is verified. 1500 w. Comptes Rendus—May 24, 1904 No. 63254 D.

Experiments upon the Resistance of the Air (Recherches Relatives à la Resistance de l'Air). Ch. Renard. A description of the Renard dynamometric balance, and its application to the measurement of atmospheric resistance. 1200 w. Comptes Rendus—May 16, 1904. No. 63252 D.

The Air Vane Dynamometer of Col. Ch. Renard (Das Windflügel-Dynamom-

We supply copies of these articles. See page 878.

eter des Obersten Ch. Renard). F. Ross. An account of the use of the apparatus in testing automobile motors. 2000 w. Zeitschr f Elektrotechnik—May 29, 1904. No. 63265 D.

Gauges.

Dimension Limits and Limit Gauges, Their Practical Uses and Results. Arthur A. Fuller. Showing the intelligent use of the limit gauge to lie at the foundation of standardizing and interchangeable systems, giving practical examples. 3000 w. Engineering Magazine—July, 1904. No. 63288 B.

Graphostatics.

The Decomposition of Forces (Ueber Kräftezerlegung). A. Kiefer. Giving solutions of a number of special problems in graphical statics. 1800 w. Schweiz Bauzeitung—May 21, 1904. No. 63261 B.

Locomotive Testing.

Locomotive Testing Plants. W. F. M. Goss. Illustrates and describes the plants at Purdue University and the plants of the Chicago & Northwestern Railroad Co., Columbia University, the Pennsylvania Railroad System at St. Louis, and of other experimenters. 8000 w. Trans Am Soc of Mech Engrs, No. 043—June, 1904. No. 62994 C.

Locomotive Testing Plant at the St. Louis Exhibition. H. W. Hanbury. Indicates the principle upon which the plant is based, and explains the difficulties in connection with the installation which have delayed its completion. Ills. 2200 w. Engng—June 17, 1904. No. 63498 A.

I. Testing Locomotives in England. G. J. Churchward. Describes the testing plant on the Great Western Railway at Swindon. II. Measured Tests in Service. W. F. Pettigrew. On the instruments and results required at a test. 2700 w. Inst of Mech Engrs—June, 1904. No. 63335 D.

Slide Rule.

An Instrument for Use with Screw-Cutting Lathes (Sur un Instrument Destiné à Faciliter l'Emploi du Tour à Fileter). M. Moehlenbruck. A form of circular slide rule with double runner, enabling the various change gears for screw-cutting to be selected without computation. 800 w. Comptes Rendus—May 24, 1904. No. 63255 D.

Spring Testing.

An Important Test of Elliptic Springs. S. A. Bullock. Describes tests made for the Interborough Rapid Transit railway to determine permanent set and proper working fiber stress. 800 w. Am Engr & R R Jour—June, 1904. No. 63158 C.

Testing Laboratory.

See Industrial Economy.

Tool Dynamometer.

Experiments with a Lathe-Tool Dynamometer. J. T. Nicholson. A record of results of over 300 serial trials, each requiring the making, recording and reducing of from 50 to 100 observations. Ills. 8500 w. Inst of Mech Engrs—June, 1904. No. 63329 D.

Experiments with a Lathe-Tool Dynamometer. J. T. Nicolson. A record of results of over 300 serial trials as the first installment of work required to give an understanding of the action of the tools used in a machine shop. 7500 w. Trans Am Soc of Mech Engrs. No. 040—June, 1904. No. 62991 C.

Weighing.

Typical Automatic Weighing Machines. Emile Guarini. Illustrates and describes machines made in England. 1500 w. Sci Am Sup—June 25, 1904. No. 63536.

POWER AND TRANSMISSION.

Compressed Air.

Tests of Air Compressors (Versuche an Luftkompressoren). Data and results of tests of single and double stage air compressors built by Meyer of Mülheim, with indicator diagrams, and valve details. 1200 w. Glückauf—May 28, 1904. No. 63245 B.

The Air Compressor. R. H. Collingham. On the design of air compressors, indicating how theoretical facts and formulæ may be made of use in the every-day practice of the drawing office and testing plate. 1800 w. Engr, Lond—June 3, 1904. Serial. 1st part. No. 63371 A.

Joint.

The Efficiency of the Universal Joint (Sur le Rendement du Joint Universel). L. Lecornu. Deriving an equation showing the relation of the angle between the two shafts to the efficiency. 1200 w. Comptes Rendus—May 30, 1904. No. 63257 D.

Mechanical Plant.

The Arcade Building Power Plant, Dayton, O. An isolated mechanical equipment for power and lighting service, and also including an ice-making and cold-storage plant. Ills. 1700 w. Eng Rec—June 18, 1904. No. 63419.

Power Plant.

The Power Plant of Princeton University. A. M. Feldman. Brief illustrated description of a plant furnishing heat, light and power for the forty buildings of the university, and planned with a view to furnishing light and heat outside of the grounds. 1000 w. Engr, U S A—June 15, 1904. No. 63401 C.

Remodeled Plant.

Remodeled Studebaker Power Plant at

South Bend, Indiana. Brief illustrated description of the changes made. 1800 w. Eng Rec—June 25, 1904. No. 63560.

Ropes.

Notes on Rope Transmission. E. A. Reuleaux. Notes and tables on the American system of rope transmission only. 1600 w. Am Mach—June 9, 1904. No. 63172.

STEAM ENGINEERING.

Boilers.

The Belleville Boilers. L. Fauveau. Translated from the French. Illustrates and describes the present Belleville boiler, and gives the history of the various stages through which it has passed. 3500 w. Jour Am Soc of Nav Engrs—May, 1904. No. 63466 H.

Corrosion.

Corrosion of Boiler Tubes. John D. Ford. A report of experimental tests to ascertain the relative corrodibility of lap-welded Bessemer steel, lap-welded, iron, seamless cold-drawn steel, and seamless hot-drawn steel boiler tubes. Ills. 4500 w. Jour Am Soc of Nav Engrs—May, 1904. No. 63467 H.

Economizers.

Economizer Calculations. W. H. Booth. Discusses the action of economizers and methods of determining the efficiency. 1300 w. Power—June, 1904. No. 63050 C.

The Efficiency of Fuel Economizers. George E. Walsh. A statement of the advantages and economy that should be expected by using economizers. 1800 w. Ir Trd Rev—June 2, 1904. No. 63060.

Engines.

Early Steam Engines. A. R. Bell. An illustrated article considering some of the earliest work of inventors. 1800 w. Mach, N Y—June, 1904. No. 63062 C.

New Hamilton-Corliss Vertical Cross Compound Engine. Illustrated detailed description of a new design. 1200 w. St Ry Jour—June 18, 1904. No. 63451 C.

Entropy.

The Entropy Diagram and Its Uses. H. Boyd Brydon. Explains its use in determining just what an engine is doing, its losses, where they are, and the effect of any changes made. 4300 w. Power—June, 1904. No. 63051 C.

Expansion.

Steam Curves. W. H. Booth. A discussion of the curves used to show the action of expanding steam. 1800 w. Elec Rev, Lond—May 27, 1904. No. 63115 A.

Explosions.

A Disastrous Boiler Explosion. Illustrated description of the terrible explosion in St. Louis on the 21st of last December, when seven water-tube boilers exploded simultaneously. Discusses the cause. 2500 w. Locomotive—April, 1904. No. 63424.

Steam Boiler Insurance. A. D. Risteen. Extracts from a lecture in the Yale Insurance Course. Considers the cause and prevention of explosions, the risks, testing, &c. 6000 w. Ir Trd Rev—June 9, 1904. No. 63164.

Feed Pumps.

Air Chambers on the Water Supply Inlets of Boiler Feed Pumps. Walter T. Ray. An illustrated description of an investigation into the cause of excessive hammering of three boiler-feed pumps in the Harrison street station of the Chicago Edison Co. 2000 w. Technograph, No. 18—1903-4. No. 63315 D.

Feed-Water.

Impure Feed-Water in Boilers. C. W. U. Adamson. Considers briefly substances in solution, salts in solution, free acids, air and other gases and oil, and indicates the general methods employed to remove them. 1800 w. Aust Min Stand—April 14, 1904. Serial. 1st part. No. 63125 B.

Purification and Automatic Feeding of Boiler Water (Wasserreinigung und Automatische Speisung). Illustrating several forms of lime and soda softeners, as well as the Körting automatic boiler feeder. 1200 w. Glückauf—June 4, 1904. No. 63248 B.

Softening and Purification of Water. J. C. W. Greth. Notes the kinds of impurities, considering some of the mechanical devices and methods employed in the purification for boiler-feed purposes, showing them to be only partially successful, and discusses the advantages of the intermittent settling tank system. General discussion. 900 w. Pro Engrs' Soc of W Penn—Feb, 1904. No. 63389 D.

Water Softening on the Southern Pacific. H. Stillman. Gives a mechanical description of the apparatus used, with illustrations. 2000 w. R R Gaz—June 24, 1904. No. 63522.

Water-Softening on the Union Pacific. A. K. Shurtleff. Gives an account of the steps taken to improve the water on a division of this road, and the results obtained. 2500 w. R R Gaz—June 24, 1904. No. 63521.

Feed-Water Heater.

A Home-made Boiler Feed Water Heater. Ernest Stein. Illustrated description. 600 w. Eng & Min Jour—June 23, 1904. No. 63513.

Exhaust Steam Boiler Feed-Water

We supply copies of these articles. See page 878.

Heaters; Hot Water Pumps and Pumping. W. D. L. Hardie. Read before the Can. Min. Inst. Discusses the objects of feed-water heaters, reviewing the progress and giving information from the writer's experience. Ills. 5000 w. Can Min Rev —May 31, 1904. Serial. 1st part. No. 63072 B.

Firing.

Coal Firing in Full Depth Regenerator Furnaces. G. W. McKee. Describes experiments made with the view of ascertaining in what way the consumption of fuel might be lessened and the efficiency of the furnace maintained. 1600 w. Pro Age—June 1, 1904. No. 63057.

Flow.

The Flow of Steam Through Nozzles. A. M. Levin. Gives a method for the solution of problems relating to this subject. 2000 w. Am Mach—June 30, 1904. No. 63579.

Hammers.

Notes on the Design of Steam Hammers. W. M. Park. Gives a rational solution of some of the mechanical problems involved in the design. 1600 w. Technography, No. 18—1903-4. No. 63312 D.

Mechanical Stokers.

The Mechanical Stoker and the Human Operator. Edwin Yawger. Presents some of the general considerations that bear on the art of combustion of fuel in boiler furnaces. 3000 w. Am Gas Lgt Jour—June 20, 1904. No. 63447.

Outflow.

Experiments on the Outflow of Steam. Prof. M. F. Gutermuth. Translated from the *Zeitschrift des Vereines Deutscher Ingenieure*. An account of experiments at the mechanical laboratory of the Technical High School at Darmstadt on the outflow of steam through openings of various cross-sectional shapes. Ills. 4500 w. Jour Am Soc of Nav Engrs—May, 1904. No. 63469 H.

Pipe Coverings.

Note on the Relative Efficiency of Heat Insulating Media. S. H. Davies. An account of experimental investigations with the object of finding a suitable covering for pipes conveying highly superheated steam. 1600 w. Engr, Lond—May 27, 1904. No. 63139 A.

Steam Pipe Covernigs. S. H. Davies. From the *Jour of the Soc. of Chem. Ind.* Results of an interesting series of experiments made by S. H. Davies. 2000 w. Mech Engr—June 4, 1904. No. 63363 A.

Reversing Gear.

The Norberg Reversing Gear. R. A. Wright. A description of the reversing gear of a large mine hoisting engine. 600 w. Am Mach—June 9, 1904. No. 63170.

Speed Regulation.

Notes on Fly-Wheels. H. H. Barnes, Jr. An outline of comparative tests of generating sets with both light and heavy fly-wheels, discussing the effect upon the uniformity of speed. 4000 w. Trans Am Inst of Elec Engrs—May 17, 1904. No. 63343 D.

The Obscure Cause of Failure of a Corliss Engine Governor to Regulate. Yestric Land. Explains the conditions and the difficulty in locating the trouble, with the final success. 1600 w. Am Mach —June 9, 1904. No. 63169.

Steam Ports.

On Port Areas for Steam Engines. M. F. Gutermuth. Translated from the *Zeitschrift des Vereines Deutscher Ingenieure*. An illustrated study of the behavior of the flow of steam and the influence of the point of cut-off upon the proportions of steam passages. 3500 w. Jour Am Soc of Nav Engrs—May, 1904. No. 63470 H.

Superheating

Superheated Steam. F. J. Rowan. Read before the Inst. of Engrs. and Shipbuilders. Reviews the history of the various investigations made in this field since 1736, describing designs of superheaters. 3500 w. Sci Am Sup—June 18, 1904. No. 63385.

The Specific Heat of Superheated Steam (Die Spezifische Wärme des Ueberlutzten Wasserdampfes). H. Lorenz. Describing investigations made at the Institute of Technical Physics at Göttingen, showing the specific heat of superheated steam to be about 0.6. 2000 w. Zeitschr d Ver Deutscher Ing—May 14, 1904. No. 63213 D.

Turbines.

Brake Tests of a 400-kw Westinghouse-Parsons Steam Turbine. Gives interesting results of a series of tests made at East Pittsburg, Pa. 1500 w. St Ry Jour —June 11, 1904. No. 63302 C.

Different Applications of Steam Turbines. A. Rateau. An account of the practical results of the writer's work in this field, describing the Rateau turbine, and giving results of various applications. Ills. 9500 w. Inst of Mech Engrs—June, 1904. No. 63330 D.

Dynamic and Commercial Economy in Turbines. Robert H. Smith. The present article discusses the fundamental principles of turbines and the applications of these principles to steam or gas turbines. 3000 w. Engr, Lond—May 27, 1904. No. 63137 A.

Fitness of the Steam Turbine for Heavy Power Service. From a paper by J. R.

We supply copies of these articles. See page 878.

Bibbins, read before the New England R. R. Club. Discusses the general principles, construction, &c. Ills. 4000 w. Ry and Engng Rev—May 28, 1904. Serial. 1st part. No. 63036.

Notes on the Steam Turbine. H. F. Schmidt. On the losses in a steam turbine, based on a study of the various curves, showing the results of tests, and attempting to find out the reason that the total steam consumption curve for all turbines is, for all practical purposes, a straight line. 2500 w. St Ry Jour—June 25, 1904. No. 63565 C.

The Rateau Steam Turbine. Walter Rappaport. Explains the action of the steam in various types of turbines, and claims that the Rateau turbine avoids the drawbacks shown in other types, describing and stating the advantages. Ills. 1200 w. Elec Rev, Lond—June 17, 1904. No. 63542 A.

The Steam Turbine as Applied to Electrical Engineering. Charles A. Parsons, G. Gerald Stoney and C. P. Martin. Paper read before the Inst. of Elec. Engrs. Reviews the development of the steam turbine, giving reports of tests made, and discussing the improvements effected. 4000 w. Elect'n, Lond—May 27, 1904. Serial. 1st part. No. 63119 A.

The Steam Turbine in Modern Engineering. W. L. R. Emmet. Gives a comparison of the Parsons and DeLaval types, and describes the Curtis turbine, giving illustrations. 2800 w. Trans Am Soc of Mech Engrs, No. 042—June, 1904. No. 62993.

The Turbine: A New Era of Steam. Arthur Warren. An illustrated article calling attention to the great advance, and the changes it is making in the engineering world. 3800 w. Rev of Revs—June, 1904. No. 63308 C.

The Zoelly Steam Turbine (Die Dampfturbine von Zoelly). J. Weishäupl. Detailed description of the machine, and data and results of tests. 3000 w. Zeitschr d Ver Deutscher Ing—May 14, 1904. No. 63212 D.

The Zoelly Steam Turbine. Illustrated description of a steam turbine of the multi-stage impulse type, in which the expansion of the steam takes place in the passages in the stationary parts of the apparatus. 2000 w. Eng Rec—June 4, 1904. No. 63100.

MISCELLANY.

Aeronautics.

The Critical Speed of Dirigible Balloons (Sur la Vitesse Critique des Ballons Dirigeables). Ch. Renard. An examination of the relation of speed to stability, showing the influence of the form and size of the balloon. 1500 w. Comptes Rendus—June 6, 1904. No. 63259 D.

The Best Inclinations for the Surfaces and Propeller Shafts of Dynamical Air Ships. Excerpt of a paper read by T. W. K. Clarke before the Aeronautical Inst. The subject is treated from a mathematical and theoretical standpoint, with the object of showing the considerations affecting the efficiency. 2000 w. Auto Jour—June 11, 1904. No. 63427 A.

Pendulum Systems.

Foucault Pendulum Systems. Ernest K. Adams. Describes a variety of Foucault pendulum suspension that might be tried for maintaining the swings of the pendulum indefinitely. Ills. 5600 w. Elec Wld and Engr—June 25, 1904. No. 63551.

MINING AND METALLURGY

COAL AND COKE.

Analysis.

A Neglected Factor in Coal Analysis. S. W. Parr. Shows the error in regarding the ash and moisture as the inert substance, and the volatile matter and fixed carbon as the true combustible, proposing a possible remedy. 900 w. Technograph, No. 18—1903-4. No. 63313 D.

Coal Tipples.

The Use of Steel for Coal Mine Tipples. George S. Rice. Abstract of a paper read before the W. Soc. of Engrs. A discussion of tipple construction, and the reasons why steel is better than wood; the vibrations caused by the introduction of shaking screens, &c. Constructional features are considered in detail. Ills. 3000 w. Eng News—June 16, 1904. No. 63409.

Coke.

The Structure of Coke and Its Applications in the Foundry (Der Koks, seine Struktur und seine Verwendung zu Giessereizwecken). Friedrich Schreiber. A study of foundry coke, with especial reference to the effect of the method of coking upon the product. 2500 w. Stahl u Eisen —May 1, 1904. No. 63275 D.

Coking.

The Coking of Hard Coal (Zur Frage

We supply copies of these articles. See page 878.

der Steinkohlenverkokung). Oscar Simmersbach. An examination of the behaviour of coal in the operation of coking, with especial reference to the nature of the coal. 3500 w. Stahl u Eisen—April 15, 1904. No. 63270 D.

Collieries.

The Eureka Collieries. An illustrated article summarizing the present methods and equipment of ten mines in Pennsylvania, near Johnstown. 2000 w. Eng & Min Jour—June 2, 1904. No. 63073.

Colorado.

The Primero Mines. R. M. Hosea. An illustrated description of the extensive plant of the Colorado Fuel & Iron Co. for the mining and coking of coal. 4800 w. Mines & Min—June, 1904. No. 63-142 C.

Electric Power.

Electricity in Colliery Work. F. J. A. Matthews. Considers in detail the application of electricity to colliery work, the methods of transmission of power, &c. Ills. 3700 w. Mech Engr—June 18, 1904. Serial. 1st part. No. 63545 A.

Electric Power in European Colleries. C. S. Vesey Brown. Gives illustrations showing typical engine rooms of the colliery plants, and motor drives, describing the working at various mines, and giving an account of the development. 2500 w. Cassier's Mag—June 1904. No. 63534 B.

Nevada.

A Nevada Coal Field. W. J. Stoneham. Describes a recently discovered coal field, the work done, the character of the coal, &c. 1000 w. Eng & Min Jour—June 23, 1904. No. 63514.

Peat.

Investigations upon the Value of Peat (Versuche über die Verwertung des Torfes). Dr. L. C. Wolff. Determinations of the calorific value of peat together with the available by-products obtained by coking. 3500 w. Zeitschr d Ver Deutscher Ing—June 11, 1904. No. 63222 D.

Preparation.

Coal Preparation at the Düsseldorf Exposition of 1902 (Ueber die Konlenaufbereitung auf der Düsseldorfer Ausstellung 1902). C. Blömeke. Describing a number of systems and devices for washing, screening and classifying coal. Two articles, 6000 w. 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—June 4, 1904. No. 63240 each D.

The New Coal Washing Plant at the Röchlingen Works at Völklingen (Die Neue Kohlenwäsche der Röchlingen Eisen und Stahlwerke in Völklingen). An illustrated description of a recent installation, with results of the preparation of coals of the Saar district, Prussia. 2500 w. Glückauf—May 21, 1904. No. 63-242 B.

The New Separation and Washing Plant of the Dahlbusch Mine (Die Neue Separation und Wäsche des Schachtes VI. der Zeche Dahlbusch). Illustrating the screens, conveyors and general arrangement of the entire plant. 1200 w. 1 plate. Glückauf—June 4, 1904. No. 63247 B.

The Screening, Washing and Briquetting Plant at Alstaden (Siebrei, Wäsche, und Brikettfabrik der Aktiengesellschaft Alstaden). An illustrated description of a modern coal handling and preparing plant recently installed near Oberhausen. 2000 w. 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—May 14, 1904. No. 63-238 D.

Working.

Methods of Working Coal in the Rhenish Westphalian Basin. Abstract from a report by Maurice Bodart. Describes the characteristic features and the methods adopted. Ills. 4500 w. Ir & Coal Trds Rev—May 27, 1904. No. 63141 A.

COPPER.

Analysis.

The Analysis of Calcines. John P. Walker. An account of a new method of determining the chemical composition of calcined copper ores. 2000 w. Eng & Min Jour—June 9, 1904. No. 63175.

Arizona.

Diamond Drilling in an Arizona Copper District. Dwight E. Woodbridge. A report of the diamond drill work. 1100 w. Eng & Min Jour—June 2, 1904. No. 63077.

Southwestern Copper Developments. Dwight E. Woodbridge. A summary of the leading camps of Arizona and Northwestern Sonora, and a discussion of the future outlook. 5000 w. Ir Age—June 2, 1904. No. 63059.

Copper-Queen.

The Phelps-Dodge Copper Interests. Dwight E. Woodbridge. Information of interest in regard to the Copper-Queen and other property. 3500 w. Ir Age—June 23, 1904. No. 63475.

Deposits.

A Curious Copper Deposit. Arthur Lakes. Abstract from a paper by J. A. W. Murdoch, describing low-grade ore worked at a profit without capital in a waterless district; and also the perfect preservation of a human body by impregnation of copper salts, probably as old as 1600 A. D. 700 w. Min Rept—May 26, 1904. No. 63022.

We supply copies of these articles. See page 878.

Siemens Process.

Studies on Siemens' Process for Winning Copper. M. DeK. Thompson, Jr. Abstract of an investigation performed at the electrochemical laboratory of the Polytechnikum at Zurich. 6000 w. Elec-Chem Ind—June, 1904. No. 63570 C.

West Australia.

Copper Mining, Ravensthorpe (W. A.). Walter F. Smith. A description of this district and its mines. 3500 w. Aust Min Stand—April 28, 1904. No. 63365 B.

GOLD AND SILVER.

Arizona.

The Tombstone Mines, Arizona. On the work of re-opening the Tombstone mines. 1800 w. Eng & Min Jour—June 9, 1904. No. 63174.

British Columbia.

Summary Report on the Valley of the Flathead River. Description by the Provincial Mineralogist in the annual report of the Minister of Mines for 1903. Ills. 8800 w. B C Min Rec—June, 1904. No. 63195 B.

Cyanide.

An Industrial Method for the Determination of the Oxygen in Working Cyanide Solutions. A. Prister. Illustrated description of a method much simpler than those formerly used. 4000 w. Jour of Chem, Met & Min Soc of S Africa—April, 1904. No. 63007 E.

Cyaniding Gold-Bearing Sulphides. J. H. Burfeind. Gives particulars of results, considering the work of Professor Christy, and of Mr. Joseph Smith. 2500 w. Min Rept—June 23, 1904. No. 63553.

Dredge.

A Gold-Mining Dredge of Recent Design. Samuel S. Wyer. Illustrates and describes a dredge designed by the writer for work in Idaho, which presents unique features. 2000 w. Eng & Min Jour—June 9, 1904. No. 63176.

Fusion.

The Fusing Point of Gold (Sur le Point de Fusion de l'Or). Daniel Berthelot. A comparison of a number of measurements by the author and others, the latest determination being 1067.4 degrees C. 1200 w. Comptes Rendus—May 9, 1904. No. 63251 D.

Idaho.

The Silver City District, Idaho. A description of the mines and their development. Ill. 2000 w. Eng & Min Jour—June 2, 1904. No. 63075.

Indo-China.

The Mines of Bong Miu, Annam. Illustration, with description of the gold mines and methods of working. 1200 w. Min & Sci Pr—June 18, 1904. No. 63561.

Mercur.

The Geology of Mercur. George H. Dern. The history of the region with description of the gold and silver ores and their peculiar formation, discussing how they were deposited. Ills. 3800 w. Mines & Min—June, 1904. No. 63145 C.

Nicaragua.

Mining in Nicaragua. H. E. West. Brief account of the gold deposits and their working. 1100 w. Min & Sci Pr—June 18, 1904. No. 63562.

Quicksilver.

Quicksilver recovered in the Cyanide Process. E. J. Sweetland. Considers the manner in which it enters into the tailings and the recovery. 600 w. Min & Sci Pr—May 21, 1904. No. 63043.

Refining.

Electrolytic Refining of Gold. Emil Wohlwill. Notes on the writer's electrolytic method of refining gold, the advantages of the process, &c. 2200 w. Elec-Chem Ind—June, 1904. Serial. 1st part. No. 63569 C.

Sampling.

Notes on Mine Valuation and Sampling. A. W. Warwick. Briefly considers the various steps of mine valuation and correct sampling. 2000 w. Min Rept—May 26, 1904. No. 62023.

Silver-Lead.

The St. Eugene Mine. E. Jacobs. A description of this mine, which is the largest silver-lead producer in British Columbia. 1500 w. Eng & Min Jour—June 16, 1904. No. 63416.

Slimes.

The Decantation Process of Slimes Treatment: Its Possibilities and Limitations. E. J. Laschinger. Discusses this process under various given conditions, showing losses incurred by carrying certain factors in treatment beyond definite limits and indicating how best economic results may be obtained. 8500 w. Jour of Chem, Met & Min Soc of S Africa—April, 1904. No. 63006 E.

Solubility.

Solubility of Gold in Certain Oxidizing Agents. Victor Lenher. Abstract of an article in the *Jour.* of the *Am. Chem. Soc.* Describes a series of experiments made and the results. 1200 w. Eng & Min Jour—June 16, 1904. No. 63414.

Witwatersrand.

Observations on the Metallurgical Practice of the Witwatersrand. Harry S. Denny. A reply to the discussion on the writer's paper. 10000 w. Jour of Chem, Met & Min Soc of S Africa—April, 1904. No. 63008 E.

We supply copies of these articles. See page 878.

The Metallurgy of Gold on the Rand Gold-Fields. Clement Dixon and M. Torrente. Gives a résumé of the metallurgical practices in these fields, showing the development of the cyanide process. Also editorial. 9500 w. Elec-Chem Ind. June, 1904. No. 63568 C.

IRON AND STEEL.

Blast Furnaces.

A Furnace Charging and Distributing Apparatus. Frank C. Roberts. Illustrated description of apparatus designed by the writer with statement of its advantages. 1700 w. Ir Age—June 23, 1904. No. 63476.

Charcoal Furnace.

The Pioneer Charcoal Furnace and Chemical Plant. A description of an interesting exhibit at St. Louis Exposition of the Pioneer Iron Company, at Marquette, Mich. 3700 w. Ir Age—June 23, 1904. No. 63477.

Charging Machine.

Improved Electric Charging Machine (Elektrisch Betriebene Block-Einsetzmaschine). Illustrated description of a traveling machine for placing ingots in reheating furnaces. 2000 w. Stahl u Eisen—June 1, 1904. No. 63279 D.

Concentration.

Concentration of Mesabi Iron Ores. Dwight E. Woodbridge. An account of the experimental work being made by the Canisteo Mining Company, of Duluth, and describing the ore deposits. 1400 w. Eng & Min Jour—June 16, 1904. No. 63412.

Electric Smelting.

See Electrical Engineering, Electrochemistry.

Elevators.

Electric Elevators for Blast Furnaces (Elektrische Antriebe von Hochofenaufzuge). C. Schiebeler. With illustrations of details of electrically operated charging devices. 1800 w. Stahl u Eisen—April 15, 1904. No. 63271 D.

Hematite.

The Preparation of Brown Hematite Iron Ores. F. Lynwood Garrison. Explains the fundamental principle of log washers or trommels, and gives an illustrated description of a plant designed by the writer. 1100 w. Eng & Min Jour—June 16, 1904. No. 63413.

Hot Blast.

The Work of Faber du Faur in the Utilization of Furnace Gases (Faber du Faur und die Verwendung der Gichtgase). Ernst Baur. An historical review of the introduction of the hot blast into German blast furnaces. 2500 w. Stahl u Eisen—May 15, 1904. No. 63276 D.

Iron District.

Vermilion Iron-Bearing District of Minnesota. Kirby Thomas. A review of the fifth monograph on this region by the United States Geological Survey. Ills. 2200 w. Mines & Min—June, 1904. No. 63146 C.

Open Hearth.

Various Processes for the Production of Low Steel in the Open Hearth Furnace (Ueber Verschiedene Verfahren zur Erzengung von Flusseisen im Herdofen). R. M. Daelen. A review of recent improvements in open-hearth steel making, presented at the Düsseldorf Convention of the Verein Deutscher Eisenhüttenleute. 3000 w. Stahl u Eisen—May 1, 1904. No. 63273 D.

Review.

Twenty-five Years of German Iron Industry (25 Jahre Deutscher Eisenindustrie). E. Schroedter. Address at the convention of the Verein Deutscher Eisenhüttenleute, with diagrams showing the progress of the iron and steel industries of various countries. 4500 w. Stahl u Eisen—May 1, 1904. No. 63272 D.

Rolling Mills.

Recent Progress in Wire-Rod and Bar Rolling-Mill Plants. Considers recent practice in England, Germany and America. Ills. 2800 w. Engng—June 3, 1904. No. 63369 A.

The New Plate Rolling Mill of the Charlotten Works (Das Neue Blechwalzwerk der Charlottenhütte). A. Ruhfus. Illustrated description of the new works at Niederschelden on the Sieg. 1500 w. 1 plate. Stahl u Eisen—June 1, 1904. No. 63278 D.

Separation.

Magnetic Separation. F. T. Snyder. Read before the Can. Min. Inst. Remarks on the development of magnetic separation, the early types of separators, the present extensive use and the results. 3300 w. Can Min Rev—May 31, 1904. No. 63071 B.

Silicon.

The Influence of Silicon on Iron (Der Einfluss von Silizium auf Eisen). F. Wüst. With microphotographs, showing the nature of the various iron alloys, and tables of the physical properties. 2500 w. Stahl u Eisen—May 1, 1904. No. 63274 D.

MINING.

Boring.

The Choice of Methods for Deep Boring (Die Wahl der Bohrmethode für Tiefe Schurfbohrungen). Paul Stein. Comparing the relative value of the dia-

We supply copies of these articles. See page 878.

mond and the percussion drill and showing the conditions governing the selection of a method. Two articles, 4000 w. Oesterr Zeitschr f Berg u Huttenwesen—May 21, June 4, 1904. No. 63239 each D.

Deposits.

Ore in Rocks of All Geological Periods. Arthur Lakes. Shows that ore depositions may be found in all rocks providing certain circumstances or conditions are present. Illustrates by examples. 1400 w. Min Rept—May 26, 1904. No. 63021.

Egypt.

Mining in Ancient Egypt. Abstract from the report of the Egyptian and Soudan Mining Syndicate. Reviews the ancient history of the mines, and their present condition. 2500 w. Min Rept—May 26, 1904. Serial. 1st part. No. 63024.

Explosives.

Nitro Explosives. Howard C. Parmelee. Describes these substances, explaining their action and analysis. 700 w. Min Rept—June 16, 1904. No. 63446.

Recent Explosives (Neue Sprengstoffe). Dr. Anton Mikolajczak. An examination of the nitro-glycerine series, with especial reference to the higher stability of dinitroglycerine. 1200 w. Glückauf—May 28, 1904. No. 63246 B.

Exposition.

Mining and Metallurgy at the Louisiana Purchase Exposition. Arthur H. Storrs. A short description of some of the exhibits. 3800 w. Mines & Min—June, 1904. No. 63147 C.

Faults.

Some Observations Concerning Faults. Arthur Lakes. An illustrated article explaining how faults are sometimes indicated on the surface, and other peculiarities. 700 w. Min Rept—June 2, 1904. Serial. 1st part. No. 63088.

Fires.

The Prevention and Extinction of Spontaneous Coal Fires in the Zwickau District (Die Entstehung, Verhütung, und Bekämpfung der durch Selbstentzundung von Kohle Hervorgerufenen Grubenbrände im Zwickauer Steinkohlenreviere). H. Brauns. A very complete account of practical methods of handling fires in coal mines. Three articles, 2 plates, 10000 w. Glückauf—May 28, June 4, 11, 1904. No. 63243 each B.

Hoisting.

A Comparison of Steam and Electric Power for Hoisting Machines (Vergleich der Betriebskräfte Dampf und Elektrizität für Fördermaschinenbetrieb). H. Laudien. Giving continuous diagrams of work, speed, resistance, etc., for mine hoists, with a summary of the extent to which the requirements are met by steam and electric motors. 3000 w. Glückauf—May 28, 1904. No. 63244 B.

Lamp.

The Bohres Electric Mine Lamp (Bohres' Elektrische Grubenlampe). Adolf Bohres. Illustrating a portable electric safety lamp with storage-battery cell and osmium incandescent lamp. 1200 w. Oesterr Zeitschr f Berg u Hüttenwesen—June 11, 1904. No. 63241 D.

Miners' Phthisis.

The Causes and Prevention of Miners' Phthisis. J. S. Haldane and R. Arthur Thomas. Abstract of a paper read before the Inst. of Min. and Met., with editorial. An investigation of the causes, concluding that the inhalation of stone dust is the principal cause, and suggesting a means of remedying this trouble. 5700 w. Eng News—June 16, 1904. No. 63408.

Mines.

Mines and Scenery. Arthur Lakes. Illustrated brief description of a typical Nevada mining region situated in the bottom of an ancient dried-up lake bed. 1400 w. Mines and Min—June, 1904. No. 63148 C.

Mistakes.

Why Some Mines Are Abandoned and Why Others Should Be Resumed. Arthur Lakes. Discusses the reasons for some mistakes of miners and investors. 2000 w. Mines & Min—June, 1904. No. 63150 C.

Ore Deposits.

On the Formation of Certain Ore Deposits. F. Klockmann. Translated from the *Zeitschrift für praktische Geologie.* A discussion of ore deposits and their origin, the theories advanced, and current views. 2000 w. Eng & Min Jour—June 16, 1904. No. 63415.

Some of the Ore Deposits of Colorado. Arthur Lakes. Illustrates and describes deposits, mostly in highly volcanic regions. 1600 w. Min & Sci Pr—June 4, 1904. No. 63186.

Rock Drills.

Trials of the Siemens & Halske Crank Percussion Rock Drill (Ergebnisse mit Kurbel - Stoss - Bohr maschinen, System Siemens and Halske). R. Goebel. Data and results of tests with electric drills at Peine, Hannover. Details of working costs are given, the current being supplied from gas engines using furnace gases. 2000 w. Glückauf—June 4, 1904. No. 63249 B.

Sketching.

Free-Hand Sketching in the Mining Field. Arthur Lakes. On the importance of teaching sketching in technical education, naming some of the uses in the field,

We supply copies of these articles. See page 878.

and offering some suggestions for education in mining sketching. 2200 w. Min Rept—June 9, 1904. Serial. 1st part. No. 63196.

Smelting.

Pyrite Smelting. A Review. Edward D. Peters. A review of a series of papers on this subject, appearing in this journal since October 10, 1903, with the object of presenting in a concise form the results and opinions reached, to draw general deductions and to discuss points needing consideration. 2800 w. Eng & Min Jour—June 2, 1904. No. 63074.

Transvaal.

Machinery Improvements in Transvaal Mines. Explains the present conditions and shows how they have caused marked progress in minimizing the amount of manual labor. The use of rock drills and improved methods of handling the ore and waste products. 2700 w. Engng—June 17, 1904. No. 63499 A.

MISCELLANY.

Mica.

Mica Deposits. Fritz Cirkel. Notes the characteristic features of mica and the uses made of it; the various species and their commercial importance; the Canadian deposits and their value; other deposits, etc. Ills. 4800 w. Can Min Rev—May 31, 1904. Serial. 1st part. No. 63070 B.

The Production of Mica in the United States. Extracts from the report of J. A. Holmes for the year 1902. 900 w. Min Rept—May 26, 1904. No. 63020.

Petroleum.

Petroleum and Its Uses. Abstract of a paper by Dr. P. Dvorkovitz read before the Inst. of Min. Engrs. Considers the uses for illuminating, lubricating and fuel purposes. 1600 w. Mech Engr—June 18, 1904. No. 63548 A.

The Gas and Oil Fields of Kansas. The first of a series of articles on these oil and gas fields, describing present conditions. 1400 w. Min Wld—June 4, 1904. Serial. 1st part. No. 63193.

The Geology of the Boulder Oil Field. Arthur Lakes. A brief explanation of the structure of this region. 500 w. Min Rept—June 2, 1904. No. 63089.

Volcanic Origin of Oil. Eugene Coste. Discussion of the paper by Robert T. Hill, on "The Beaumont Oil Fields, with Notes on other Oil Fields of the Texas Region," claiming that it has been proved that the origin of oil is inorganic and the result of solfataric volcanic emanations. 3800 w. Jour Fr Inst—June, 1904. No. 63-342 D.

Radio-Activity.

Radio-Active Minerals. R. W. Brock. A record of results of tests of a number of minerals. 1500 w. Eng & Min Jour—June 2, 1904. No. 63076.

Tin.

Determination of Tin in Tailings and Slimes. George L. Mackenzie. Abstract of a paper before the Inst. of Min. and Met. Describes the scheme of assay employed by the writer. 1300 w. Eng & Min Jour—June 9, 1904. No. 63178.

On the Assay of Tin. J. H. Collins. Abstract of a paper read before the Inst. of Min. and Met. Briefly describes recent experiments showing that some varieties are soluble. 600 w. Eng & Min Jour—June 9, 1904. No. 63177.

Tin Scrap.

Tin Scrap Recovery Processes. John B C. Kershaw. Gives details of all the processes which have attained industrial trial, with remarks upon operating cost and upon the future of the industry. Ills. 3000 w. Elec Rev, N. Y.—June 18, 1904. No. 63411.

Zinc.

Magnetic Concentration of Zinc Ore in Virginia. C. Q. Payne. Describes the ores and their treatment. Ills. 2000 w. Eng & Min Jour—June 23, 1904. No. 63512.

Zinc-Blende.

Luminescent Zinc-Blendes. A. S. Earle and W. J. Sharwood. Describes an extensive vein of ore recently found in California, giving analysis of the ore and showing the zinc-blende to be the luminescent constituent. 1500 w. Eng & Min Jour—June 23, 1904. No. 63511.

RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

Car Service.

Per Diem, as Applied by Car Service Associations in Their Industrial Rule. W. M. Prall. Read at convention of the Nat. Assn. of Car Service Mgrs. An explanation of the object of these rules and their underlying principle. 1200 w. Ry Age—June 17, 1904. No. 63455.

Fast Run.

Some Features of the Great Western

We supply copies of these articles. See page 878.

Record Run. Charles Rous-Marten. Considers the coal consumption, steam pressure, &c. 2800 w. Engr, Lond—June 10, 1904. No. 63439 A.

The Record Run on the Great Western Railway. Charles Rous-Marten. Briefly describes the road over which the run was made and gives details of the work, explaining why it was undertaken. 4800 w. Engr, Lond—May 20, 1904. No. 63015 A.

Train Handling.

The Cause and Remedy for Freight Trains Breaking in Two. Two short papers by M. V. Quinn and C. P. Cass, discussing this subject. 4400 w. St. Louis Ry Club—May 14, 1904. No. 63310.

MOTIVE POWER AND EQUIPMENT.

Brakes.

An Important Application of the Storage Air-Brake System at Newark, N. J. Illustrated detailed description of the car equipment, compressor station, equipment, design of the system, &c. 2800 w. St Ry Jour—June 25, 1904. No. 63564 C.

Duplex Straight Air and Automatic Brake. J. P. Kelly. An explanation of the method of piping the New York Air Brake Co.'s Duplex Straight Air and Automatic Brake for switch engine and tender. 1500 w. Loc Engng—June, 1904. No. 63166 C.

Braking Power.

Basis of Unbraked Weight per Axle versus Ninety Per Cent. Plan for Passenger Equipment Cars. F. M. Nellis. Presented at the Buffalo Air Brake Convention. Discusses the inferiority of the 90 per cent. basis, and reports favorably on the uniform unbraked weight plan, as shown by an experimental train. 1600 w. Loc Engng—June, 1904. No. 63167 C.

Car Lighting.

See Electrical Engineering, Lighting.

Cars.

A New Dynamometer Car. Illustrated description of a car recently put in service by the International Correspondence Schools of Scranton, Pa. 1500 w. Ry & Engng Rev—June 18, 1904. No. 63452.

Experience in the Maintenance and Repair of Steel Freight Cars. Gives results of a recent inquiry as to current experience and practice in the maintenance and repair of these cars. 4800 w. Eng News—June 23, 1904. No. 63488.

Special Cars for Local Traffic at the St. Louis Exhibition; Wabash Railway. Brief illustrated description of side-door cars with steel underframes. 500 w. Eng News—June 9, 1904. No. 63179.

Steel Car Design. A. Stucki. Gives information based on several years' work in designing and building cars, supplemented with valuable data from the testing room. Gives analysis of stresses, arch-bars and axles in the present number. Diagrams. 1500 w. R R Gaz—June 17, 1904. Serial. 1st part. No. 63458.

The Giesecke Automatic Unloader for Railway Wagons. Illustrates a number of cars to which this device has been applied, describing the working. 1200 w. Col Guard—May 27, 1904. No. 63126 A.

The Problems of the Master Car Builder on the Electrified Steam Road. H. H. Vreeland. Also editorial. Shows that an extensive substitution of electricity for steam power would cause almost a complete revolution of repair-shop methods. 3000 w. St Ry Jour—June 25, 1904. No. 63567 C.

The Use of Steel in Passenger Car Construction. William Forsyth. Read before the M. C. B. Convention. Urges the use of steel in building stronger passenger cars, giving a design of car with steel underframe, and much of the body of steel. Ills. 2700 w. Ry & Engng Rev—June 25, 1904. No. 63577.

Coke Car.

Coke Car for the Cambria Steel Company. Plans and description of 50-ton steel hopper bin coke cars. 600 w. R R Gaz—June 17, 1904. No. 63457.

Fire-Box.

The Broton Locomotive Boiler with Water-Tube Fire-Box. Abstract of a paper by Johann Broton, published in the *Zeitschrift des österreichischen Ingenieur- und Architekten-Vereines.* Illustrated detailed description, with statement of advantages. 4500 w. Bul Int Ry Cong—May, 1904. No. 63121 E.

Heating Surface.

Heating Surface and Boiler Power. L. B. Jones. Compares the performance of a locomotive on the Pennsylvania R. R. with one on the Michigan Central, showing that a boiler with 2,640 sq. ft. of heating surface can maintain an output equal to the one with 3,505 sq. ft. 1700 w. R R Gaz—June 24, 1904. No. 63519.

The Value of Heating Surface. Lawford H. Fry. Discussing the relative value of the various parts of the heating surface in a locomotive. The present article gives a preliminary survey. 3800 w. R R Gaz—June 24, 1904. No. 63517.

Leaks.

To Locate Blows on Tandem Compound Engines. S. H. Draper. Suggestions for locating the blowing of steam by sound. 700 w. Loc Engng—June, 1904. No. 63168 C.

Locomotives.

Automatic Control of Locomotives. Illustrated description of apparatus control-

ling the throttle of a locomotive, and the system of automatic signalling. 800 w. Sci Am—June 18, 1904. No. 63384.

Baldwin Four-Cylinder Balance Compound for the Burlington. Illustrated general description. 600 w. R R Gaz—June 3, 1904. No. 63105.

Big Locomotive Overloading and Locomotive Failures. Gives five questions sent to leading railroad officials, with the replies received. 8000 w. Am Engr & R R Jour—June, 1904. No. 63156 C.

Compound Locomotives. Charles S. Lake. A discussion of the subject of compounding, and the practice in Great Britain. Concludes that the compound locomotive is far from a perfect machine, but capable of development to much greater excellence. 3000 w. Prac Engr—May 27, 1904. No. 63042 A.

Eight-Coupled Locomotive for the Queensland Government Railways. Two-page plate, illustration, and description. 800 w. Engng—May 27, 1904. No. 63128 A.

Eight-Wheel Passenger Locomotive for the London & North-Western. Illustrated description of a new fast passenger engine. 400 w. R R Gaz—June 24, 1904. No. 63520.

Four-Cylinder Balanced Compound for the Prussian State Railways. Illustrated detailed description of a locomotive on exhibition at St. Louis, a type used on the Prussian State Railways. 600 w. R R Gaz—June 24, 1904. No. 63516.

Four-Cylinder Balanced Compound Locomotive, New York Central Ry. Illustrates and describes an Atlantic (4-4-2) engine designed by F. J. Cole. 1200 w. Eng News—June 23, 1904. No. 63485.

Four-Cylinder Compound Locomotive, Paris-Orleans Railway. Illustrations, description and principal dimensions. 600 w. Engr, Lond—June 3, 1904. No. 63373 A.

Four-Cylinder De Glehn Compound Locomotive. Inset, with detailed description and general dimensions of the 4-4-2 type of the Paris-Orleans Railway of France. The illustrations indicate the construction, with the exception of a few details, of the new Pennsylvania locomotive of this type. 1500 w. Am Engr & R R Jour—June, 1904. No. 63155 C.

Four-Cylinder Locomotives at the St. Louis Exhibition. Brief descriptions of the types shown. 3300 w. Engr, Lond—May 27, 1904. No. 63132 A.

Locomotives at the St. Louis Exhibition. H. W. Hanbury. Briefly notes the important features of the transportation exhibits and begins a survey of the exhibits of the United States. 3800 w. Engng—May 27, 1904. Serial. 1st part. No. 63129 A.

Locomotive for the Great Central Railway. Principal dimensions and illustrations of a powerful engine of the Atlantic type. 700 w. Engr, Lond—June 10, 1904. No. 63443 A.

Mallet Articulated Compound Locomotive, B. & O. R. R. Illustrated detailed description of the heaviest locomotive ever built. 700 w. Ry & Engng Rev—May 28, 1904. No. 63035.

New Consolidation Locomotives for the Oregon Short Line. Illustrated description of recently built heavy locomotives. 500 w. Ry Age—June 24, 1904. No. 63,571.

Rebuilding Locomotives—Philadelphia & Reading. S. F. Prince, Jr. An illustrated article giving examples of rebuilding. 500 w. R R Gaz—June 24, 1904. No. 63518.

Some Old High-Speed Engines. Herbert T. Walker. An illustrated article on some English express engines of historical interest. 3300 w. R R Gaz—June 17, 1904. No. 63461.

Vauclain Four-Cylinder Balanced Compound. Illustrated description of a 4-4-2 type for passenger service on the Chicago, Burlington & Quincy railway. 500 w. Am Engr & R R Jour—June, 1904. No. 63,157 C.

Locomotive Testing.

See Mechanical Engineering, Measurement.

Machine Tools.

Railroad Shop Tools. An illustrated description of the present state of the art, and the changes made necessary by the use of high-speed tool steel. 1000 w. R R Gaz—June 17, 1904. Serial. 1st part. No. 63460.

Motor Coaches.

Railroad Motor Coaches Near London. W. B. Paley. Describes the cars introduced on the Great Western railway. 1400 w. R R Gaz—June 10, 1904. No. 63185.

Oscillations.

Model to Illustrate the Oscillations of a Locomotive. H. von Borries. Abstract of a paper read before the Verein für Eisenbahnkunde. Illustrates and describes this model. 1700 w. Bul Int Ry Cong—May, 1904. No. 63122 E.

Train Resistance.

Train Resistances and Locomotive Efficiencies (Die Bewegungswiderstände der Eisenbahn fahrzenge und die Leistungsfähigkeit der Lokomotiven). H. von Borries. A discussion of the performance of steam locomotives in the light of the high-speed electric trials. 2500 w. Zeitschr d ver Deutscher Ing—May 28, 1904. No. 63217 D.

We supply copies of these articles. See page 878.

Underframes.

The Design of a Steel Underframe of Standard Shapes for Freight Cars. Fritz B. Ernst. Gives design made up of standard shapes, with the exception of the bolsters, showing the method by which the different parts may be calculated. 5500 w. Ry Age—June 17, 1904. No. 63454.

Water Purification.

See Mechanical Engineering. Steam Engineering.

Wheels.

Specifications for Car Wheels. C. B. Dudley. Specifications prepared for the American Society for Testing Materials, containing important improvements which are explained by the writer. 2800 w. Am Engr & R R Jour—June, 1904. No. 63159 C.

NEW PROJECTS.

Africa.

The Swakopmund-Windhuk Narrow Gauge Railway in German Southwest Africa (Trassierung, Bau und Leistungsfähigkeit der Schmalspurigen Eisenbaln Swapokmund-Windhuk in Deutsch-Südwest Afrika) Major Pophal. An account of the location, construction and operation of 307 kilometres of railway in the country of the Hereros. 7000 w. Glasers Annalen—June 1, 1904. No. 63235 D.

Borneo.

The British North Borneo Railway. An Illustrated account of conditions and the power of the railway, the rules enforced, &c. 1200 w. Loc Engng—June, 1904. No. 63165 C.

New Lines.

The Great Western and Great Central New Railways. Describes new lines in England, giving a description of the construction, the difficulties and information of interest. Ills. 3000 w. Engr, Lond—May 27, 1904. No. 63134 A.

Oklahoma.

The Eastern Oklahoma Railway Line and Bridges. F. R. Patten. An illustrated description of the line and its construction. 3500 w. Ry Age—June 17, 1904. No. 63456.

Peru.

See Industrial Economy.

South America.

South American Railway Building. Charles M. Pepper. Information concerning lines under construction and projected in the different countries. 2500 w. Ry Age—June 3, 1904. No. 63090.

PERMANENT WAY AND BUILDINGS.

Coal Handling.

Coal Shipping Plant at Hoboken, D., L. & W. R. R. Illustrates and describes an installation on the McMyler system, adapted to the tidewater conditions of a coal-handling road. 1000 w. Ry & Engng Rev—May 28, 1904. No. 63037.

Crossings.

Some Modern Appliances Connected with Railway Crossings and Points O. R. Williams. Read befoe the Inst. of Engrs. & Shipbuilders in Scotland. Considers these appliances, stating the reasons why they are wanted, the qualities they ought to possess, &c. 2500 w. Prac Engr—June 10, 1904. Serial. 1st part. No. 63430 A.

Location.

Location of the Clinch Valley Division, N. & W. Emile Low. Deals especially with the location between St. Paul and Coeburn, Va., where some unusual problems were solved. Ills. 2500 w. R R Gaz—June 10, 1904. No. 63184.

Pier Shed.

A Steel Pier Shed for the Central Railroad of New Jersey. Brief illustrated description. 400 w. Ry Age—June 24, 1904. No. 63572.

Rails.

Some Notes on the Creeping of Rails. Samuel Tobias Wagner. A report of a series of observations made for the Philadelphia and Reading Railway Company upon the creeping rails at a number of points on their lines. 4000 w. Pro Am Soc of Civ Engrs—May, 1904. No. 62,-997 E.

Roundhouse.

New Roundhouse, C. M. & St. P. Ry. at Galewood, Ill. Plan and description. 1600 w Ry & Engng Rev—June 25, 1904. No. 63575.

Shops.

Danville Shops of the Chicago & Eastern Illinois Railway. Illustrated detailed description of the new shops at Oaklawn, east of Danville, and their equipment. 3500 w. Ry Mas Mech—June, 1904. No. 63161.

Improvements at the Oelwein Shops, Chicago Great Western Ry. Illustrates and explains the changes made in the original equipment of these shops. 6500 w. Ry & Engng Rev—June 25, 1904. No. 63576.

Repair Shops for Small Roads. Francis G. Daniell. Suggestions for design, equipment, &c. 1500 w. St Ry Jour—June 18, 1904. No. 63449 C.

Signaling.

Signals on the Interborough Rapid Transit Lines in New York City. An illustrated detailed description of the scheme adopted, which is a departure from any previous installation. 3300 w. Ry Age—June 17, 1904. No. 63453.

We supply copies of these articles. See page 878.

Storehouse.

The Storehouse System at Altoona. George L. Fowler. An explanation of the method of receiving, storing, distributing and transferring material, giving forms used. 3000 w. Eng News—June 2, 1904. No. 63459.

Terminal.

Excavation and Retaining Wall for the Pennsylvania R. R. Terminal Station, New York City. Brief illustrated description of the contract plans for the underground terminal and its construction. 3000 w. Eng News—June 2, 1904. No. 63081.

Tie Timber.

Proposed Improvements in Ties and Rail Fastenings. Abstract of Bulletin No. 50, published by the Bureau of Forestry, dealing with economical features of the production and use of ties and of forms of rail fastenings, prepared by Hermann von Schrenk. Ills. Also editorial. 9000 w. Ry & Engng Rev—June 11, 1904. No. 63305.

Timber.

Some Problems in the Use of Timber by Railroads. Hermann von Schrenk. Discusses the tie problem of supply, and timber preservation. 2000 w. Jour Worcester Poly Inst—May, 1904. No. 63318 C.

Treenails.

The Use of Screwed Wood Bushes (Treenails) in Wooden Sleepers for Increasing the Resistance of Spikes. Mr. Schwabach, in *Glasers Annalen für Gewerbe und Bauwesen*. Describes methods employed by the "Dubelwerke" Company, for fixing rails more securely. Ills. 1500 w. Bul Int Ry Cong—May, 1904. No. 63123 E.

Tunnel Ventilation.

The Ventilation of the Albespeyre Tunnel, France. Dr. Alfred Gradenwitz. An account of the large size machinery required and the difficulties met with. Ills. 1400 w. Eng Rec—June 4, 1904. No. 63102.

Tunnels.

See Civil Engineering, Construction.

STREET AND ELECTRIC RAILWAYS

Batteries.

On the Calculation of Line Batteries. W. E. Winship. Discusses the calculation of storage-batteries used in railway work for the purpose of maintaining the line pressure at points distant from the generating stations, comparing the results with those obtained by the use of copper. 2200 w. Trans Am Inst of Elec Engrs—April, 1904. No. 63160 D.

Berlin.

Recent Elevated Practice in Berlin. John P. Fox. An illustrated article describing how noise was largely prevented, the road made attractive, &c. 2800 w. St Ry Jour—June 4, 1904. No. 63152 C.

California.

Notes on the San Diego and Coronado Railway Systems. Illustrates and describes the equipment, the double-deck cars, and interesting features in general. 3500 w. St Ry Jour—June 4, 1904. No. 63153 C.

Canton, Ohio.

Some Details of an Electric Railway Power Station at Canton, Ohio. Gives illustrated description of interesting details from the standpoint of design, in the station serving the Canton-Akron railway. 1800 w. Eng Rec—June 25, 1904. No. 63559.

Derby.

Derby Electricity Works and Tramways. An illustrated description of extensions, and changes being made at Derby. 2500 w. Elect'n, Lond—June 10, 1904. Serial. 1st part. No. 63434 A.

Electric Locomotives.

Control System, Motors and Shoes of the Baltimore & Ohio Locomotives. Particulars and illustrations of these electric locomotives. 1100 w. St Ry Jour—June 25, 1904. No. 63563 C.

Electric Locomotives for the New York Central & Hudson River R. R. Illustrations and descriptions of these machines which differ radically in their electrical features from any hitherto constructed. 1500 w. Eng News—June 2, 1904. No. 63080.

Exposition.

Electric Transportation Within the World's Fair Grounds. Cloyd Marshall. Information concerning the intramural electric railway, electric automobiles, launches, &c. 1500 w. Elec Wld & Engr—June 4, 1904. No. 63110.

Feeders.

The Distribution of Electrical Energy for Large Railway Systems. (Ueber die Zuführung Elektrischer Energie für Grössere Bahnnetze) W. Reichel. Dis-

We supply copies of these articles. See page 878.

cussing especially the feeder arrangements of the high-speed, military railway, Marienfelde-Zossen. 6000 w. Elektrotech. Zeitschr—June 9, 1903. No. 63211 B.

Fire Car.

Elevated Car for Fire Fighting. Illustrated description of a novel car equipment for fire protection used on the elevated railway of Chicago. It consists essentially of an outfit of chemical extinguishers of large capacity housed in a fireproof car body. 1500 w. St Ry Jour—June 11, 1904. No. 63301 C.

High Speed.

High-speed Electric Railway Experiments on the Marienfelde-Zossen Line. Alexander Siemens. Read before the Inst. of Elec. Engrs. A short history of the trials made on this military railway and of the preparation for them and results. 4800 w. Elect'n, Lond—June 10, 1904. Serial. 1st part. No. 63435 A.

High Tension.

High Tension Transmission for Electric Railways. W. J. Davis, Jr. Read befor the New England St. Ry. Club. Considers present practice, discussing regulation, connections, construction, and insulators. 2000 w. St Ry Jour—June 25, 1904. No. 63566 C.

Interurban.

Interurban Electric Railway Practice in Indiana. Information from a paper by Robert P. Woods, read before the Indiana Engineering Society. Ills. 4500 w. St Ry Jour—June 18, 1904. No. 63450 C.

The Canton and Akron Railway. Outlines the history of this line which is a part of the system controlled by Tucker, Anthony & Company, giving illustrated description and account of the management and operation. 7800 w. St Ry Jour—May 28, 1904. No. 63028 C.

Italy.

Railway Politics and Electric Railways in Italy (Eisenbahnpolitik und Elektrischer Bahnbetrieb in Italien) Pietro Lanino. A review of the relations between steam and electric railways in Italy. 2000 w. Elektrotech Zeitschr—May, 26, 1904. No. 63202 B.

Leicester.

Leicester Corporation Electric Tramways. Illustrated detailed description of a trolley system constructed on the latest designs. 10800 w. Tram & Ry Wld—May 12, 1904. No. 63002 B.

Main Line.

The Liverpool and Southport Railway (Chemin de Fer de Liverpool à Southport) M. Debeul. General description of the third-rail equipment of the branch of the Lancashire and Yorkshire railway, between Liverpool and Southport. 2000 w. Génie Civil—May 28, 1904. No. 63228 D.

New Orleans.

The Power Plants of the New Orleans Railways Company. An illustrated detailed description of the plants, and information of related interest. 4000 w. St Ry Jour—June 18, 1904. No. 63448 C.

Operation.

The Operation of Street Railways in the Interests of the Residents (Rücksichtuahme bei Herstellung von Strassenbahnen auf die Interessen der Anlieger) W. Mende. An examination of the German law in connection with street railway operation. 4000 w. Zeitschr d Ver Deutscher Ing—June 11, 1904. No. 63223 D.

Polyphase.

Single versus Polyphase Generators in Alternating-Current Railway Work. W. A. Blanck. A consideration as to the selection of the generators delivering the energy to the system. 1300 w. Elect'n, Lond—May 27, 1904. No. 63120 A.

Safety Appliances.

Report of the Commission on Safety Appliances for Electric Railways. (Vorschlag der Sicherheits Kommission betreffend Sicherheitsvorschriften für Elektrische Bahnanlagen). The preliminary report submitted to the Electrotechnical Society for discussion. 3000 w. Elektrotech Zeitschr—June 2, 1904. No. 63,208 B.

Scarborough.

Scarborough Electric Tramways. Illustrated detailed description of the lines to this seaside resort in England. The exceptional feature is the passage of the line right over the roof of the Aquarium. 1400 w. Tram & Ry Wld—May 12, 1904. No. 63003 B.

Terminal.

An Improved Terminal for Handling the Heavy Coney Island Crowds—Brooklyn Rapid Transit Company. Illustrates and describes the new terminal plan for handling the enormous traffic at this resort. 2000 w. St Ry Jour—June 11, 1904. No. 63300 C.

Tramways.

Overhead Tramway Construction. Deals with the design, selection, arrangement and erection of overhead line material, discussing standard practices, and pointing out the leading features of the best design. 3300 w. Elec Rev, Lond—May 27, 1904. No. 63117 A.

Walsall.

Municipal Tramways at Walsall. An illustrated account of this electric tramway undertaking 3000 w. Tram & Ry Wld—June 9, 1904. No. 63483 B.

We supply copies of these articles. See page 878.

EXPLANATORY NOTE—THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. Certain journals, however, make large extra charges for back numbers. In such cases we may have to increase proportionately the normal charge given in the Index. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

Serial publications are indexed on the appearance of the first installment.

SPECIAL NOTICE.—To avoid the inconvenience of letter-writing and small remittances, especially from foreign countries, and to cheapen the cost of articles to those who order frequently, we sell coupons at the following prices:—20 cts. each or twelve for $2.00, thirty-three for $5, and one hundred for $15.

Each coupon will be received by us in payment for any 20-cent article catalogued in the Index. For articles of a higher price, one of these coupons will be received for each 20 cents; thus, a 40-cent article will require two coupons; a 60-cent article, three coupons; and so on. The use of these coupons is strongly commended to our readers. They not only reduce the cost of articles 25 per cent. (from 20c. to 15c.), but they need only a trial to demonstrate their very great convenience—especially to engineers in foreign countries, or away from libraries and technical club facilities.

Write for a sample coupon—free to any part of the world.

CARD INDEX.—These pages are issued separately from the Magazine, printed on one side of the paper only, and in this form they meet the exact requirements of those who desire to clip the items for card-index purposes. Thus printed they are supplied to regular subscribers of THE ENGINEERING MAGAZINE at 10 cts. per month, or $1.00 a year; to non-subscribers, 25 cts. per month, or $3.00 a year.

THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
American Shipbuilder. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Autocar. *w.* Coventry, England.
Automobile. *m.* New York.
Automobile Magazine. *m.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Brick Builder. *m.* Boston.
British Architect. *w.* London.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin American Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Cassier's Magazine. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.

Electrical Engineer. *w.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electric Club Journal. *m.* Pittsburg, Pa.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Electrochemical Industry. *m.* New York.
Electrochemist and Metallurgist. *w.* London.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Engineering Review. *m.* London.
Eng. Soc. of Western Penna. *m.* Pittsburg, U.S.A.
Engineering Times. *m.* London.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Ice and Refrigeration. *m.* New York.
Ill. Zeitschr. f. Klein u. Strassenbahnen. *s-m.* Berlin.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Metallurgist. *m.* Boston.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery *b-m.* Fort Monroe, U.S.A
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A.
Locomotive. *m.* Hartford, U. S. A
Locomotive Engineering. *m.* New York.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metal Worker. *w.* New York.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Minerva. *w.* Rome.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci Press. *w.* San Francisco.
Mining Reporter. *w.* Denver, U. S. A
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Mouvement Maritime. *w.* Brussels.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *w.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
North American Review. *m.* New York.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg- & Hüttenwesen. *w.* Vienna.
Ores and Metals. *w.* Denver, U. S. A.
Pacific Coast Miner. *w.* San Francisco.
Page's Magazine. *m.* London.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Progressive Age. *s-m.* New York.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Gen. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Engng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Tijds. v h Kljk. Inst. v Ing. *qr.* Hague.
Traction and Transmission. *m.* London.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
Wiener Bauindustrie Zeitung. *w.* Vienna.
World's Work. *m.* New York.
Yacht. *w.* Paris.
Zeitschr. d. Mitteleurop. Motorwagen Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.
Zeitschr. f. Elektrotechnik. *w.* Vienna.

CURRENT RECORD OF NEW BOOKS

NOTE—Our readers may order through us any book here mentioned, remitting the publisher's price as given in each notice. Checks, Drafts, and Post Office Orders, home and foreign, should be made payable to THE ENGINEERING MAGAZINE.

Discount Book.

The Thomas Discount Book. Edited and compiled by Millward T. Thomas. Size, 8 by 5 in.; pp. 81. Price, cloth, $1; leather, $1.25. Williamsport, Pa.: Millward T. Thomas.

In many lines of business it is customary to allow discounts from the list prices of goods, and where there are combinations of several discounts, the figuring of the net price is a tedious operation, and may often give rise to errors. In order to avoid these troubles, and to smooth the way for the busy accountant and merchant, the tables in this book have been compiled. They include discounts from 2½ to 90 per cent., both simple and combined, and are arranged in convenient form, so that by entering a table with the list price, the net price is at once found. But this is not the only function which these tables can perform, for they can be applied to finding discounts for specified list and net prices, to making list prices when the discount and the net price are known, to adding any per cent. of profit upon the cost, to comparing prices, and to other uses. The book has a marginal index, is of a handy size and is well bound in flexible cloth or leather.

Iron and Coal.

National Iron and Steel, Coal and Coke Blue Book. Second Edition. Edited by B. H. Morwood. Size, 9 by 6 in.; pp. 890. Price, $7.50. Pittsburg: R. L. Polk & Co.

The magnitude of the iron and coal business in the United States makes it very important, if not absolutely necessary, to have a work of reference which shall give authentic information about the various individuals and corporations engaged in these great industries. Such information, arranged in convenient form, is contained in the present "blue book," which, to begin with, has an alphabetical index of iron and steel products, with references to the manufacturers of the respective articles. Next comes the names of iron and steel companies, grouped according to the general character of the works, and then follows a list of practically all the corporations and firms in the United States, Canada and Mexico, which operate plants for the production of iron and steel, giving date of incorporation, capital stock, board of directors, names of partners and principal officers, description of works, including the railroads they are situated on, capacity of plants, and other data concerning each company, with cross references showing by whom the different works are controlled or owned. There follows an alphabetical list of directors, officers, managers, superintendents and other officials, with the names of their respective companies, and then comes a list of blast furnaces and iron and steel works, grouped by States and towns. The latter part of the book contains the data relating to coal and coke. There are alphabetical lists of the coal operators and coke manufacturers of the United States, and there is a list arranged by States and districts of all the producing coal mines, with the method of mining, tonnage and other information about each mine. From the mere statement of its contents, it can readily be seen how valuable this "blue book" must prove to everyone interested in iron, steel, coal, coke and their products.

BOOKS RECEIVED.

Cross-Tie Forms and Rail Fastenings, with Special Reference to Treated Timbers. (Bulletin No. 50 of U. S. Bureau of Forestry.) By Hermann von Schrenk. Washington: U. S. Department of Agriculture.

L'Industrie Aurifère au Transvaal; Son Passé—Son Avenir. By Albert Michaut. Price $2.00. Paris: A. Lahure, 9 Rue de Fleurus.

Moody's Manual of Corporation Securities. 1904 Edition. John Moody, Editor; C. L. F. Bridge and Louis W. Holschuh, Associate Editors. Price, cloth, $10; flexible leather, $12. New York and Chicago: Moody Publishing Co. London: Effingham Wilson.

Oil Engines. Second Edition. By A. H. Goldingham, M. E. Price, $2. New York: Spon & Chamberlain. London: E. & F. N. Spon, Ltd.

General Index to the Street Railway Journal, by Subjects and Authors, from Oct., 1884, to Dec., 1903. Price, $5. New York: McGraw Publishing Company.

Report of Proceedings of the International Fire Prevention Congress, London, 1903. By Ira H. Woolson, E. M., Official Representative for the City of New York. New York: Office of the President of the Borough of Manhattan.